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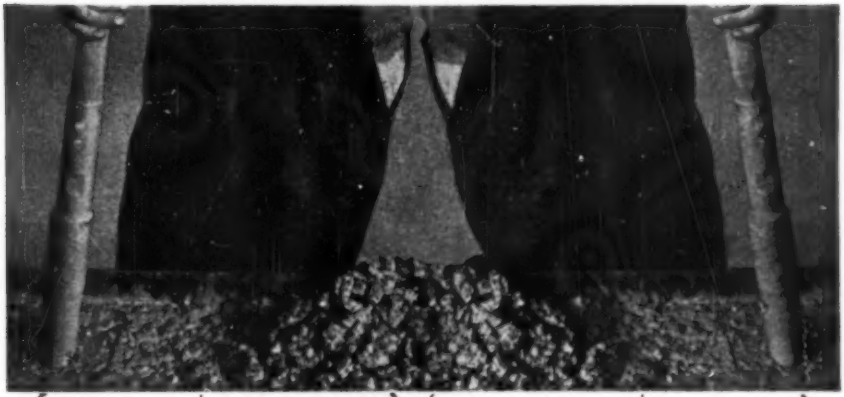

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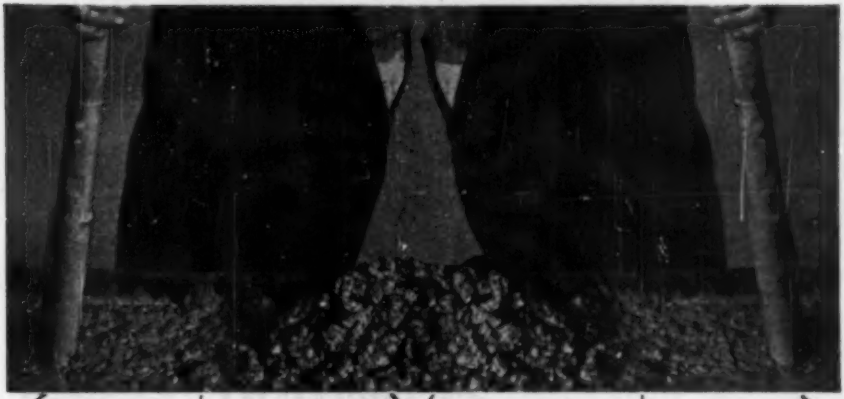

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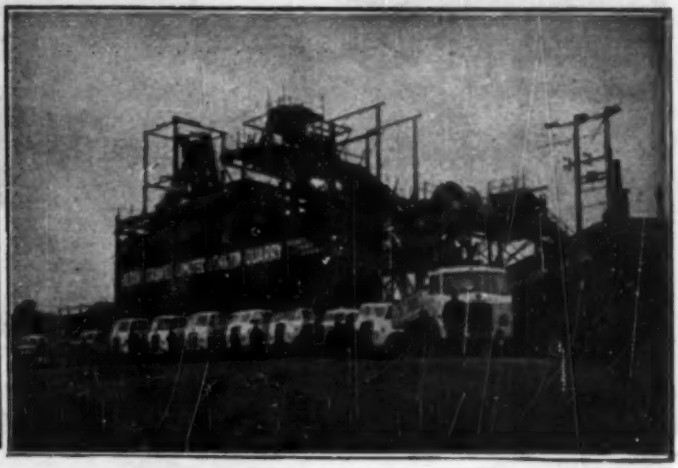

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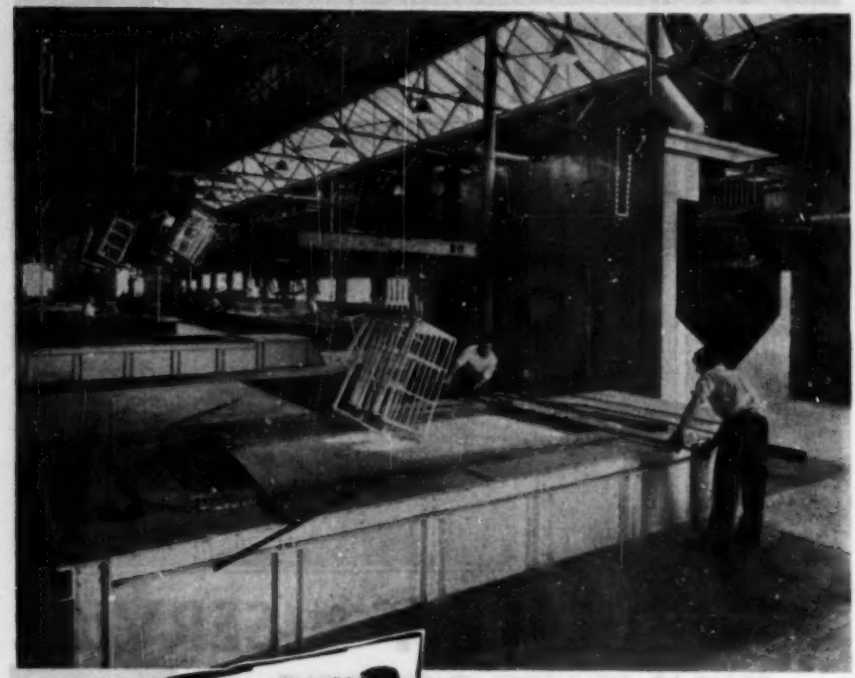

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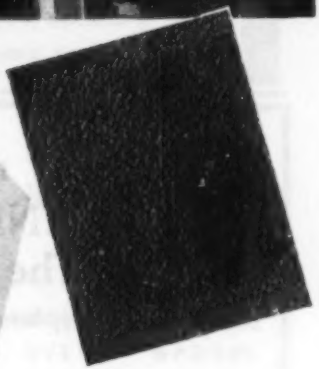

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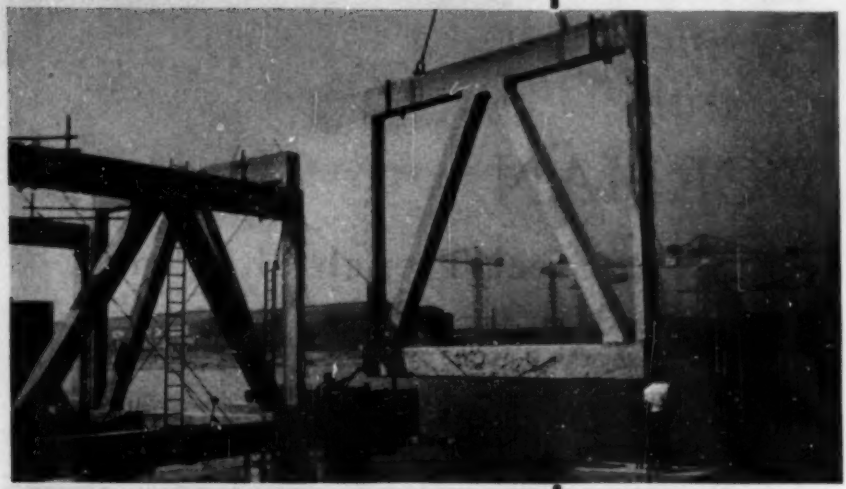

View showing the placing in position of a precast concrete head-frame during construction of the super-tanker berths at Tranmere, reproduced by courtesy of the Mersey Docks and Harbour Board

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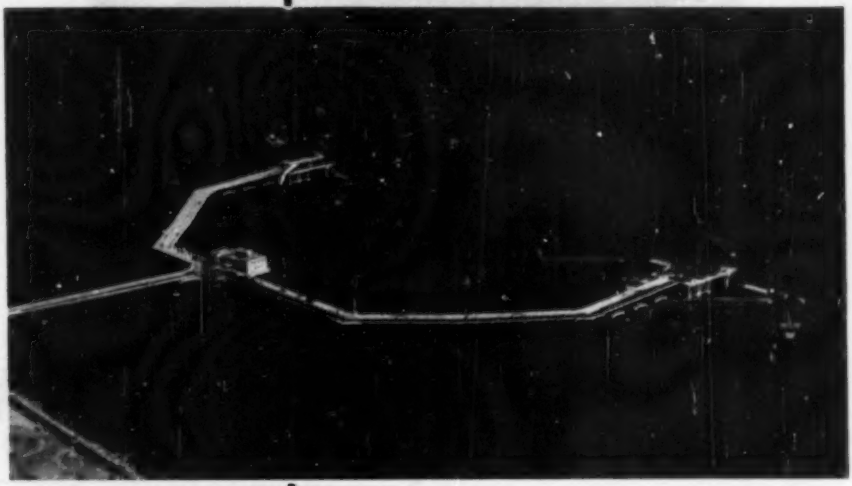

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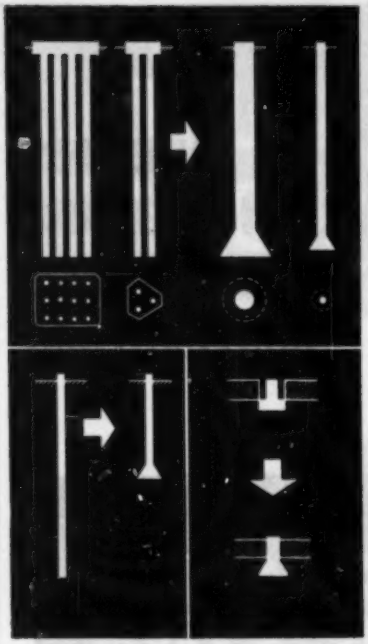

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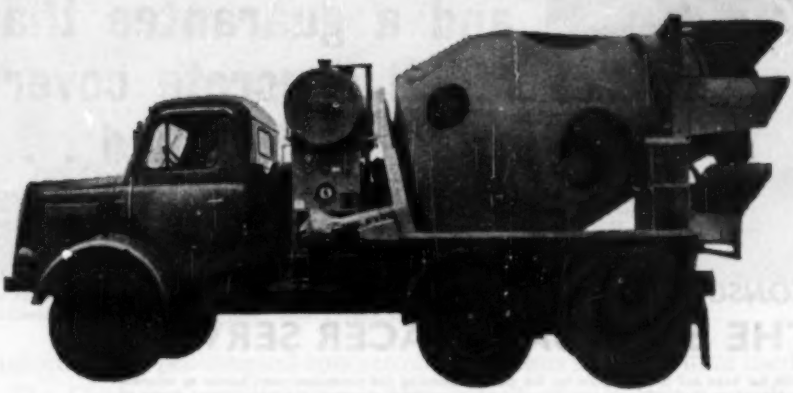

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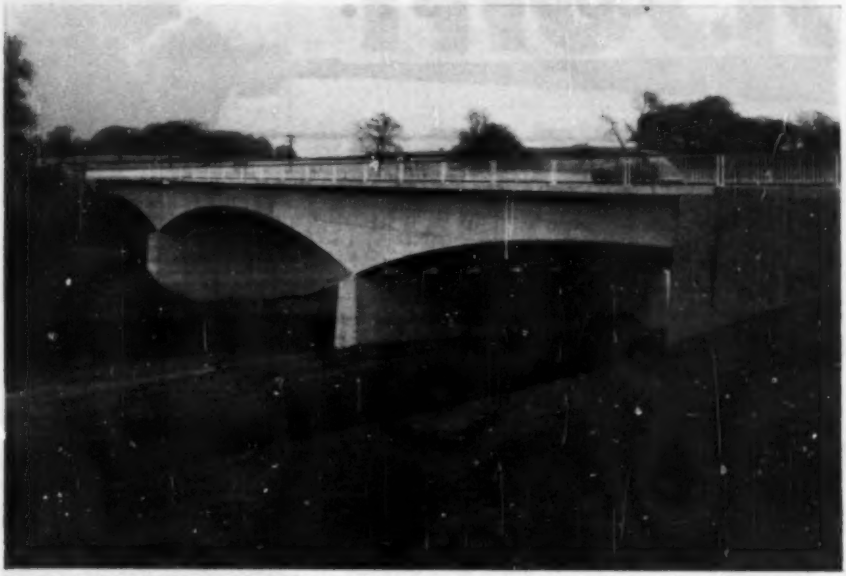

Agent Authority to the Ministry of Transport: West Riding County Council. Engineer: S. Maynard Lovell, O.B.E., E. B.D., T.D.
Main Contractors for the Wetherby By-pass Scheme: Crowley, Russell & Company Limited

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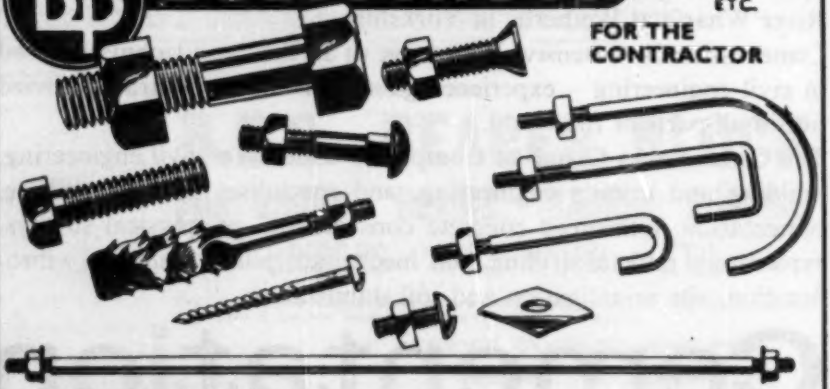

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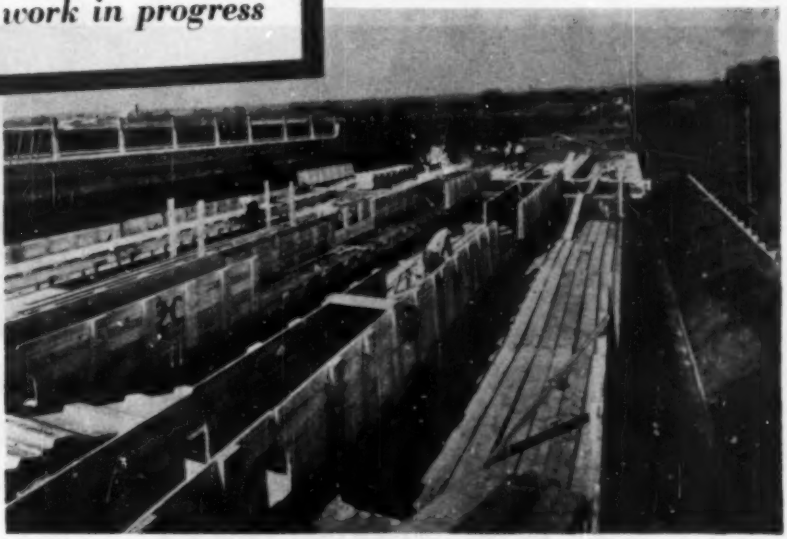

County Engineer—H. S. Andrews Esq. M.I.C.E., M.I.Mun.E.

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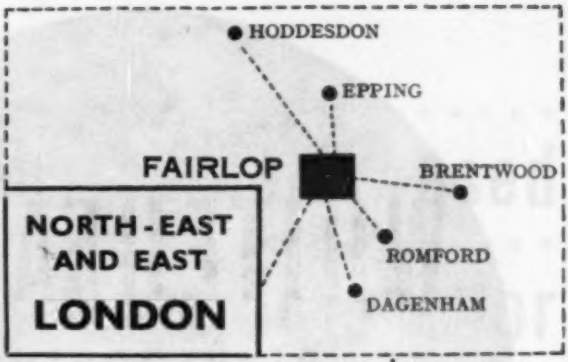

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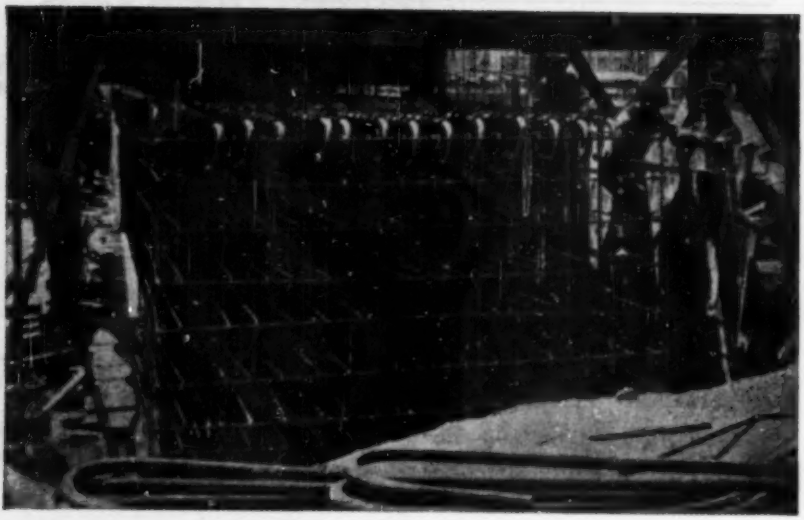

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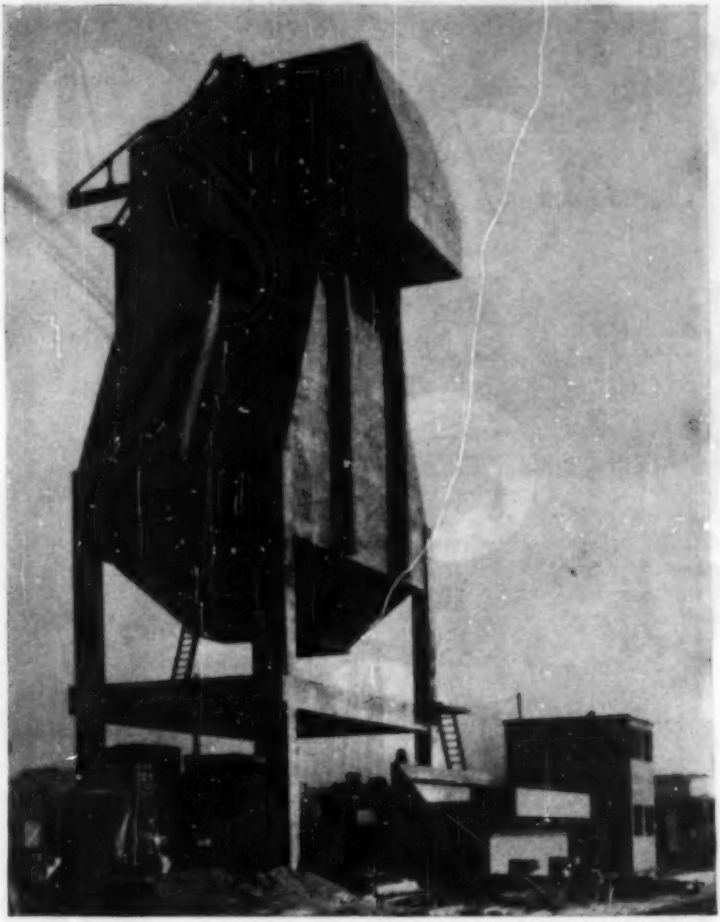

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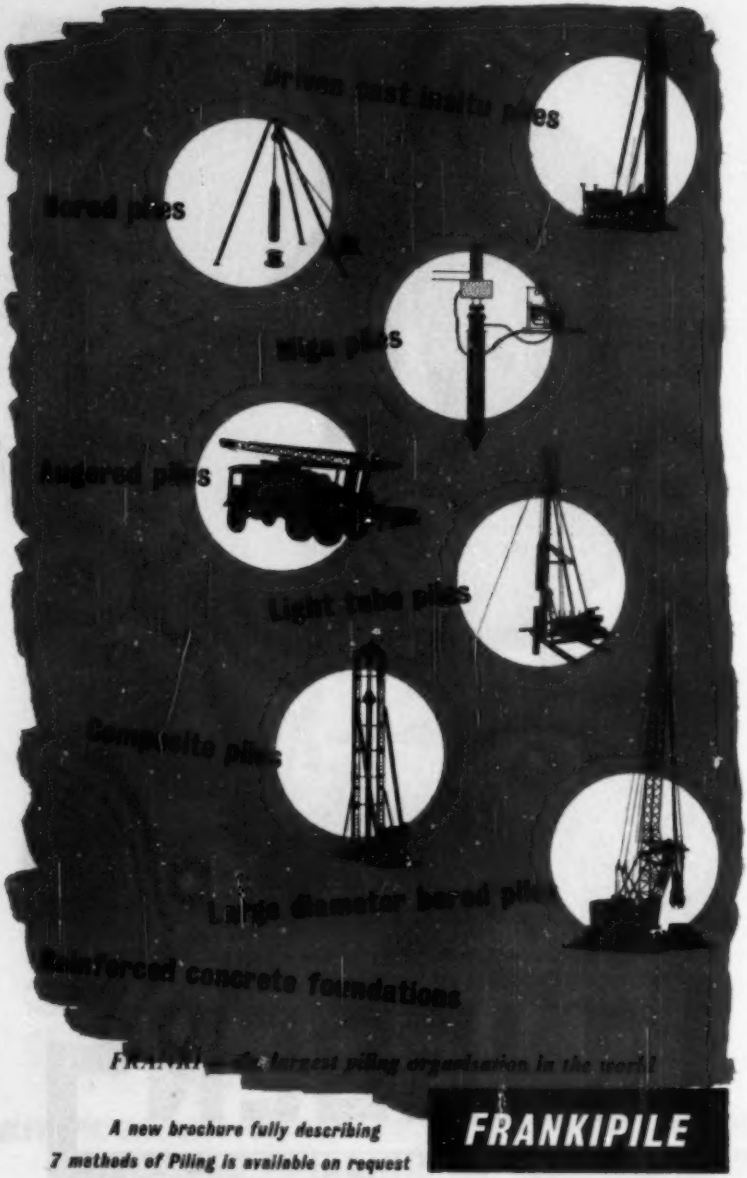

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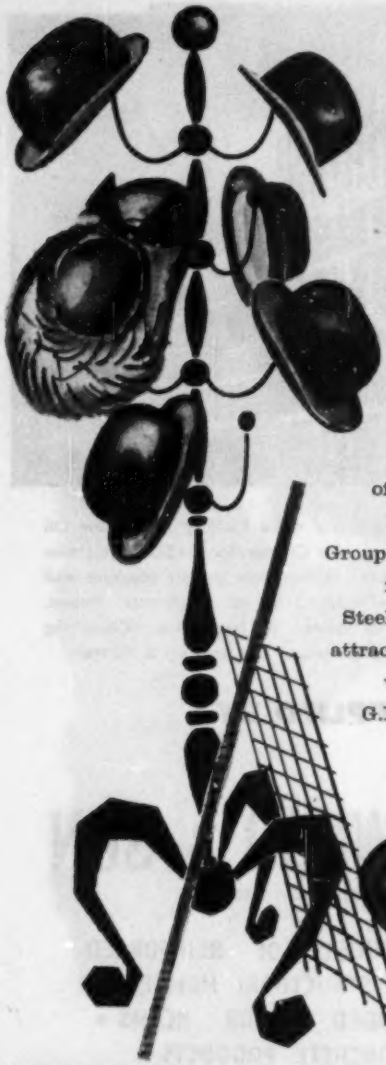

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Sponsor: Transair Ltd.
Architects: Clive Pascall and Peter Watson.
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Consulting engineers for the prestressed concrete apron: A. J. and J. D. Harris.
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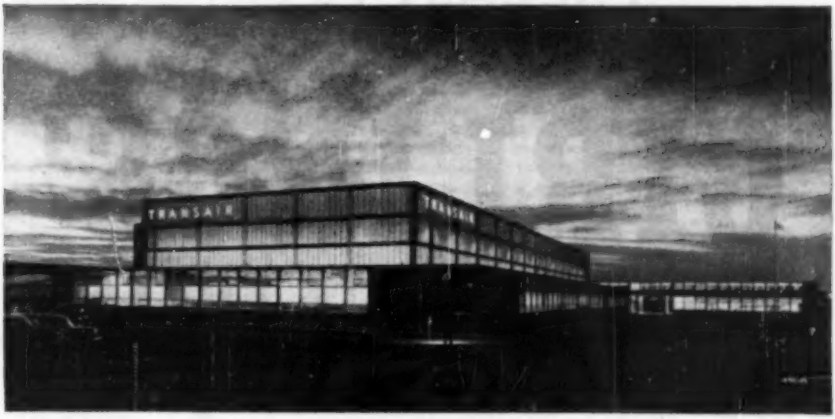

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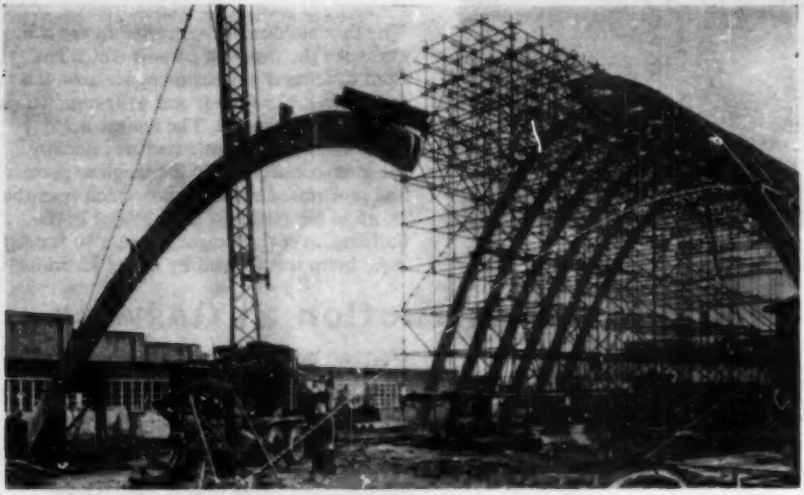

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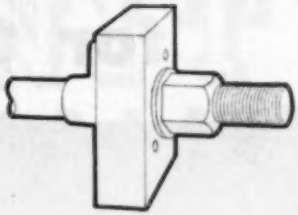

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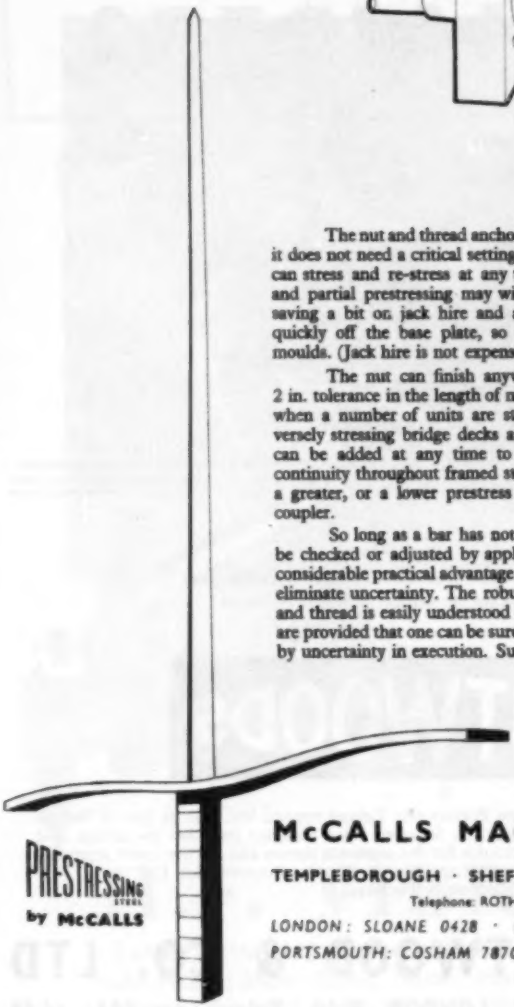

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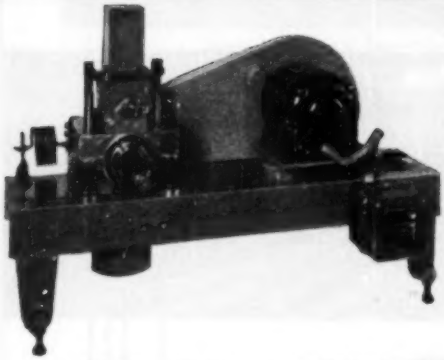

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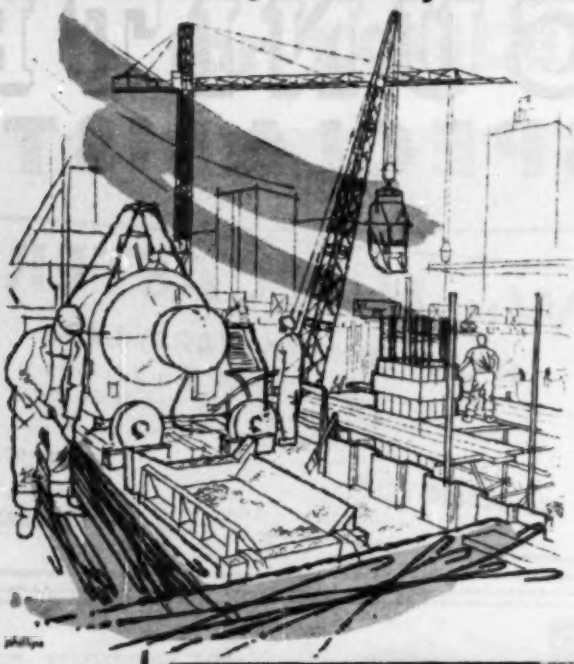

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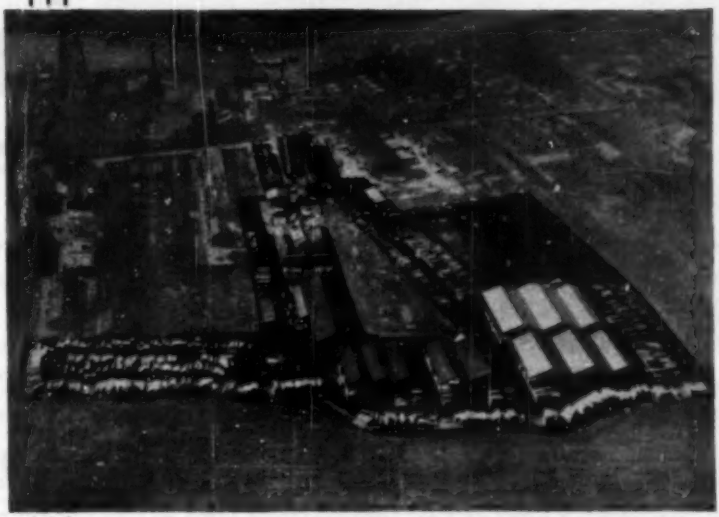

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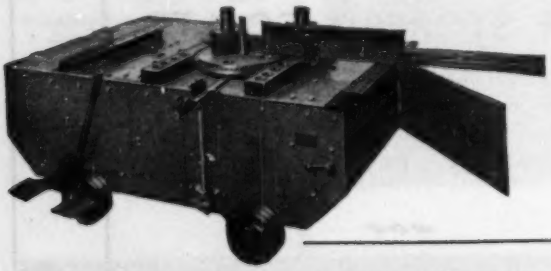

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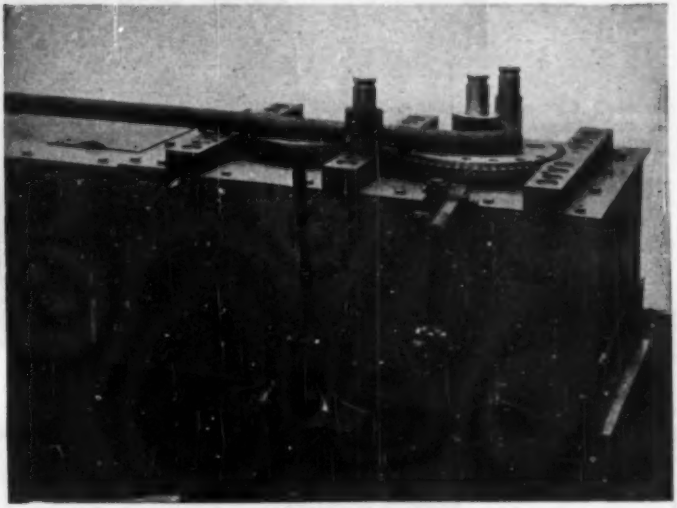

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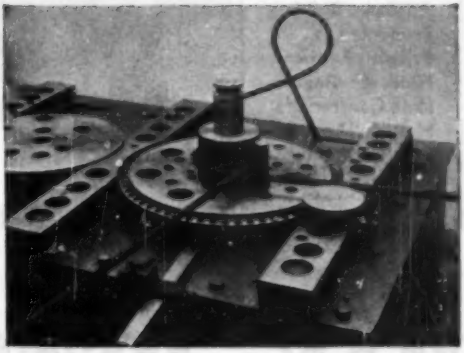

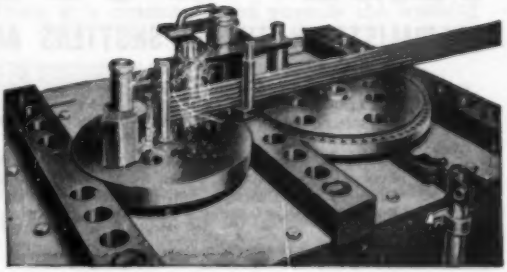

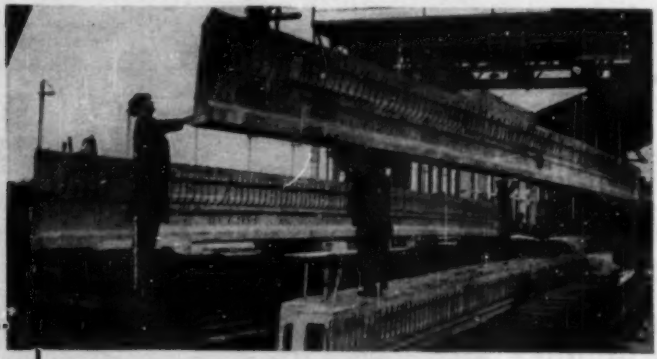

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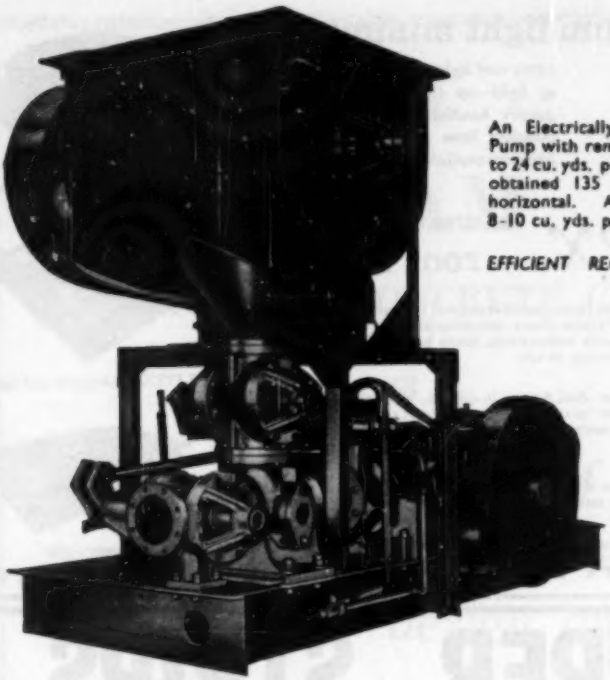

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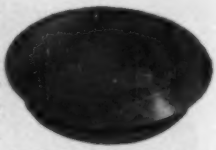

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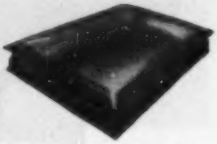

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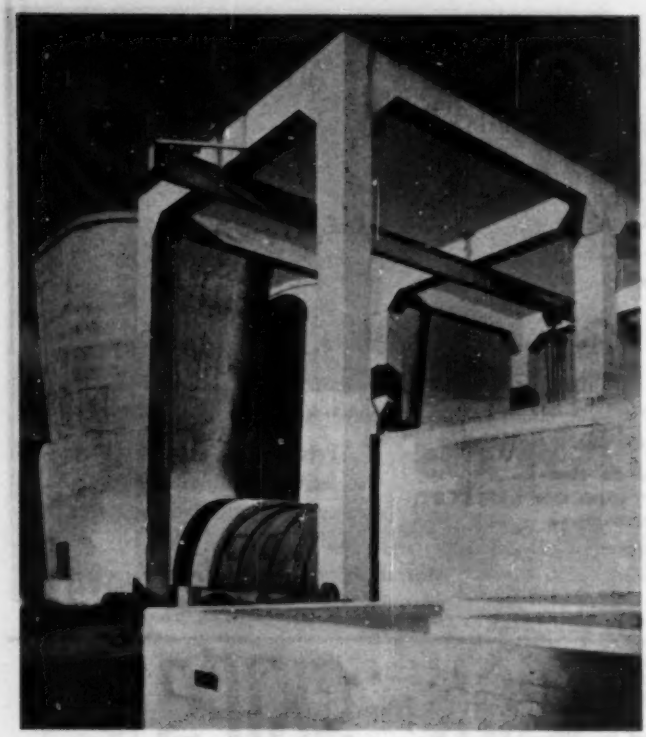

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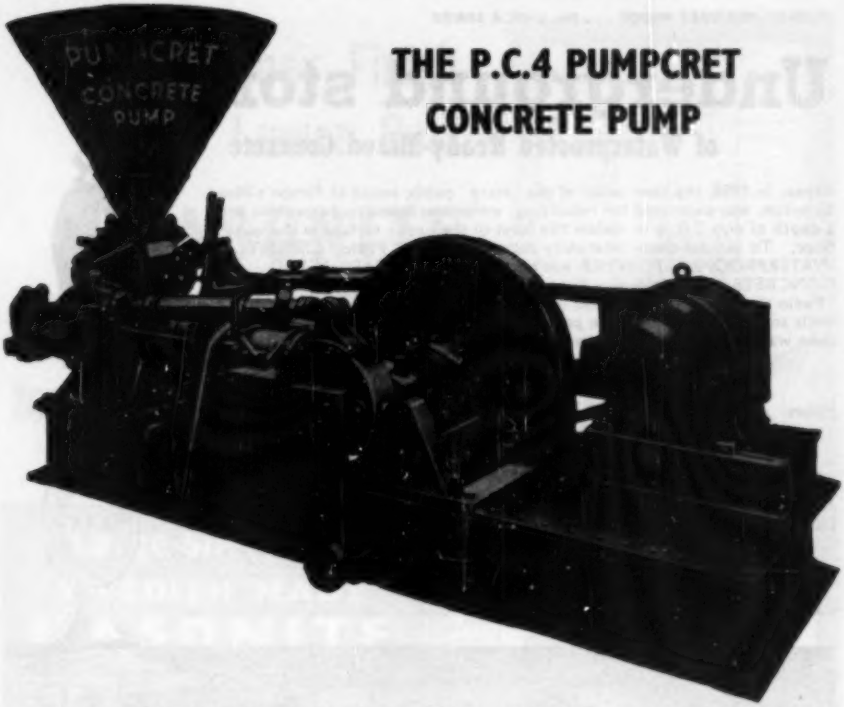

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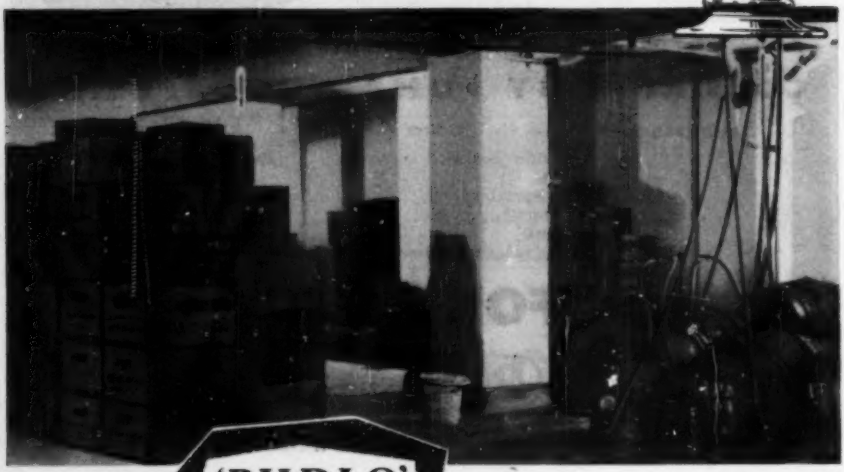

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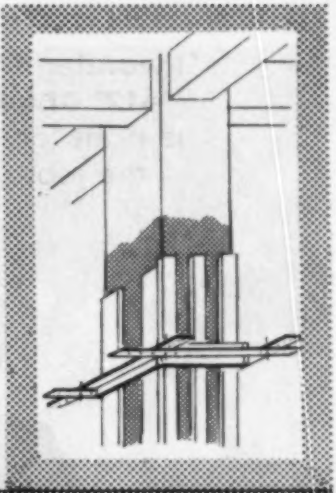

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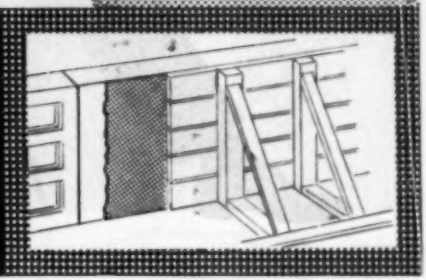

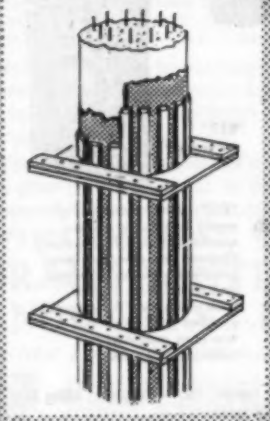

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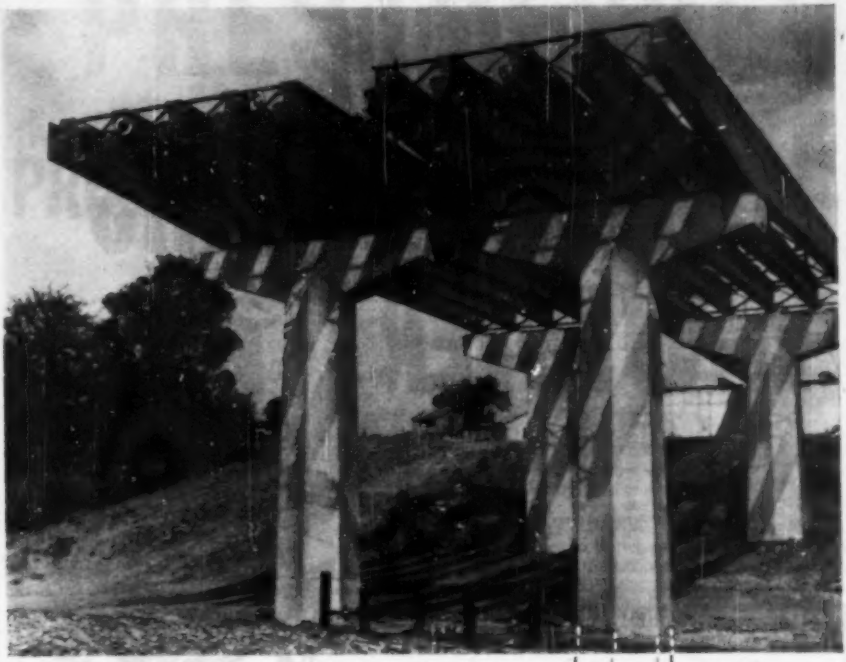

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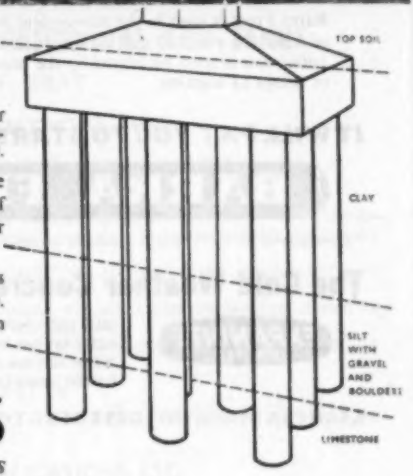

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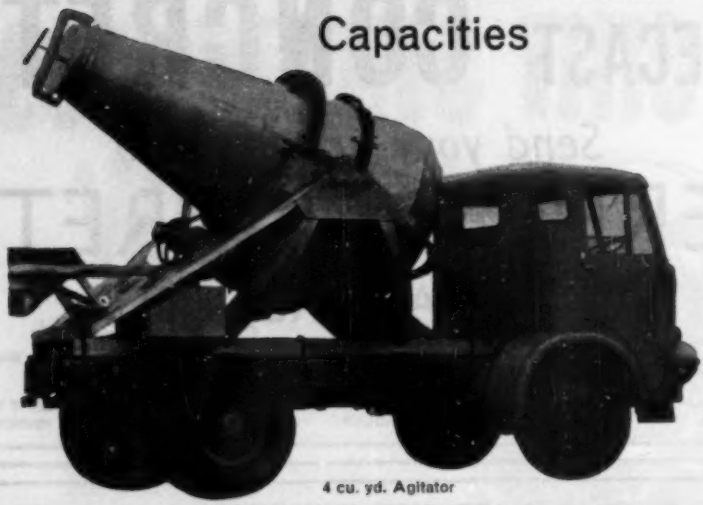

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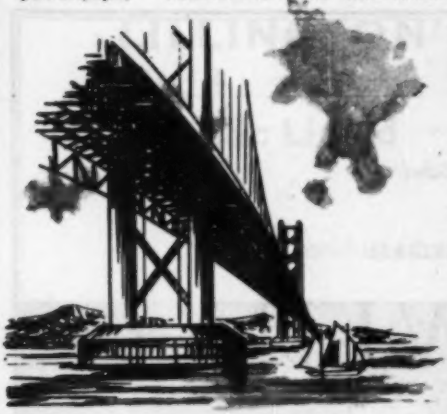

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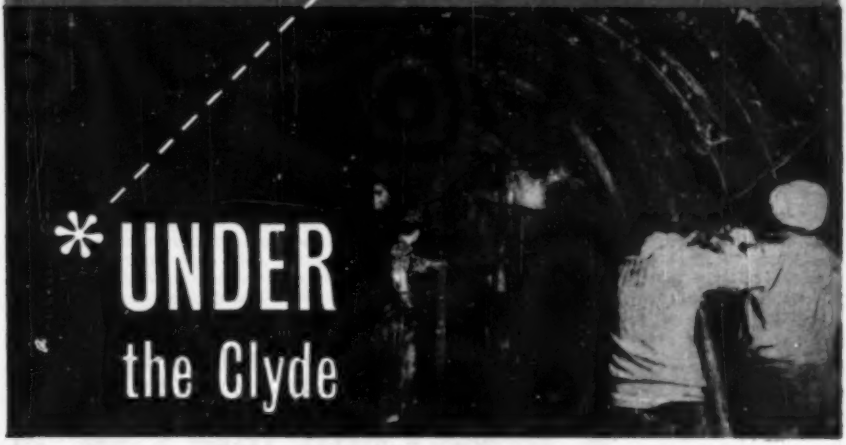

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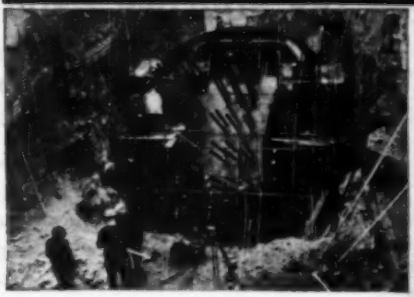

Rylands were called on to provide a minimum breaking load of 350 tons for each unit and actual tests are as high as 381 tons. The total weight of strand in these anchorages is about 630 tons.

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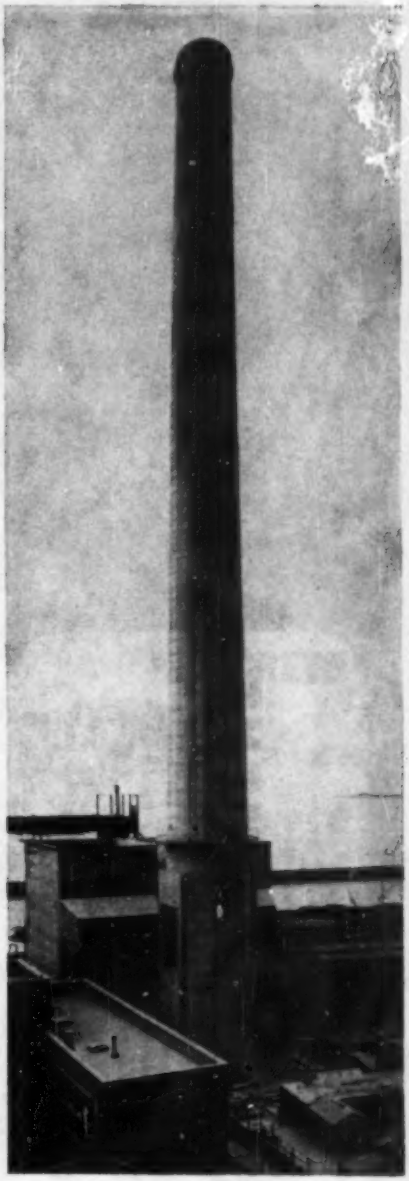

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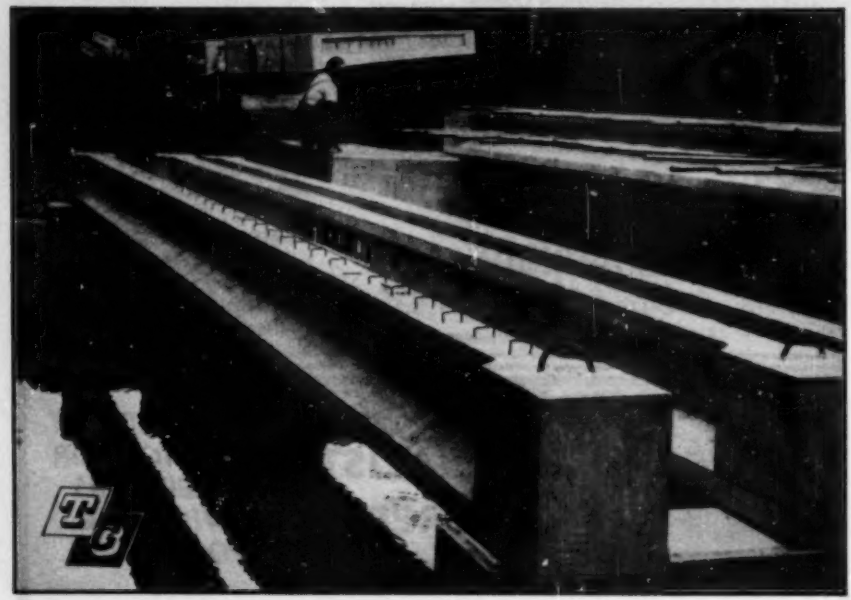

New road bridge during construction on A.50 at Fostons, Derbyshire, showing 40-ft. prestressed beams (pretensioned steel) designed to M.O.T. requirements. Main Contractors: D. T. Bullock & Co. Ltd., Aldridge, Staffs. By courtesy of the County Surveyor of Derbyshire—S. Melvew, Esq., O.B.E., B.Sc., M.I.C.E., A.M.T.P.I.

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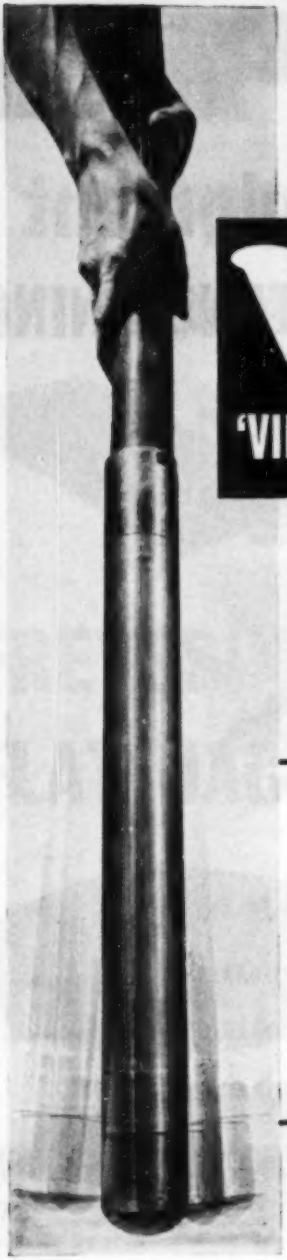

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SVO 35	1¼ in.	18 in.	10,000	0.70 mm.
SVO 36V	1$\frac{5}{16}$ in.	18 in.	10,000	0.90 mm.
SVO 45	1¾ in.	19½ in.	10,650	0.82 mm.
SVO 46V	1$\frac{13}{16}$ in.	19½ in.	10,650	1.15 mm.
SVO 60	2⅜ in.	25 in.	9,600	1.25 mm.
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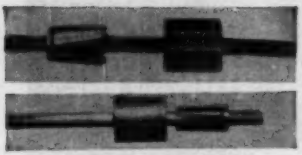

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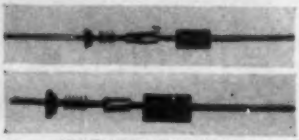

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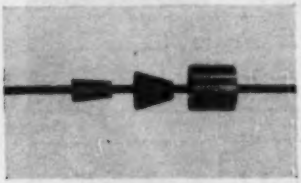

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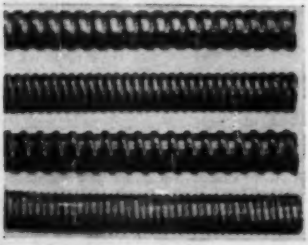

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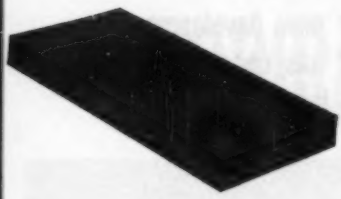

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15	5.90	17
22	8.66	41
25	9.84	54
27	10.6	64
30	11.8	81
35	13.8	114
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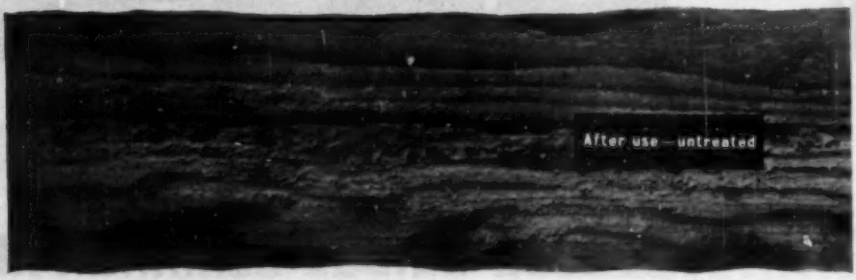

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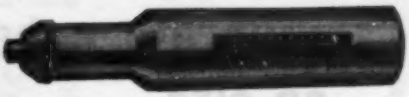

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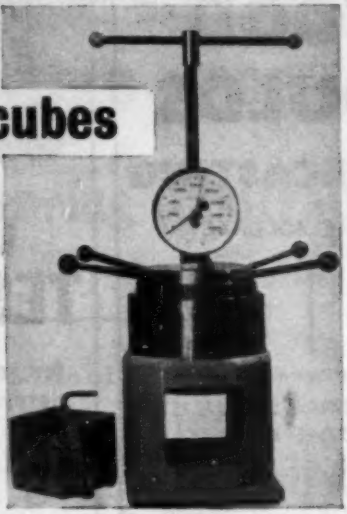

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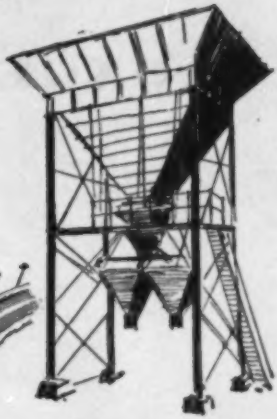

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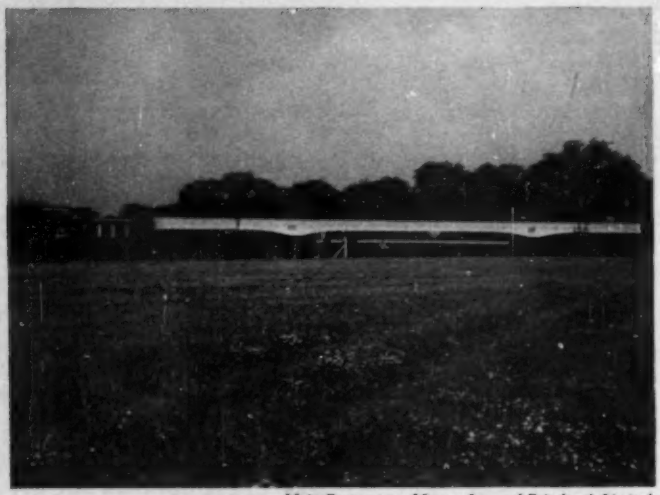

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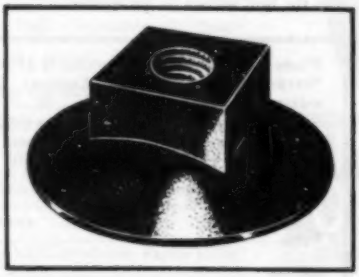

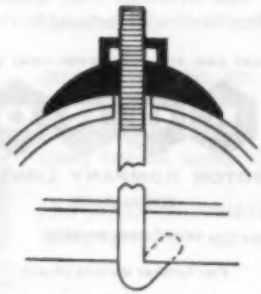

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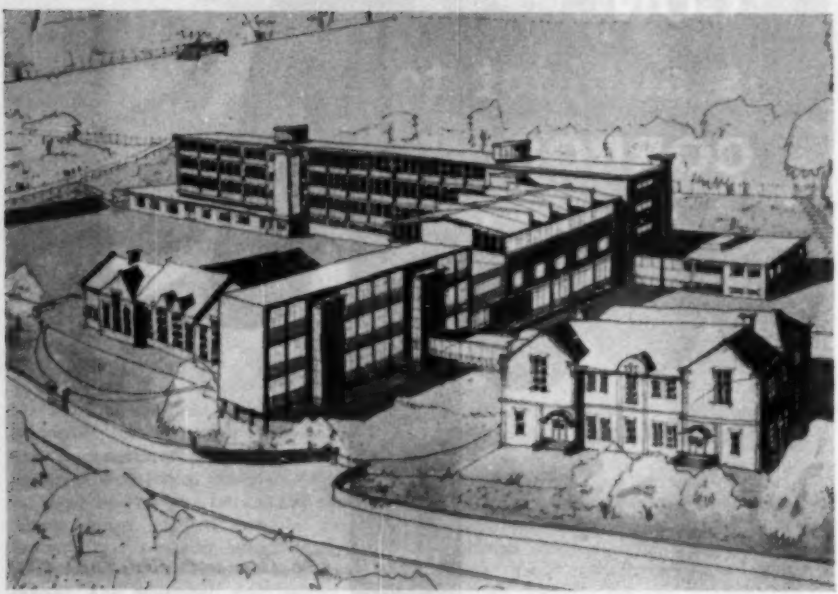

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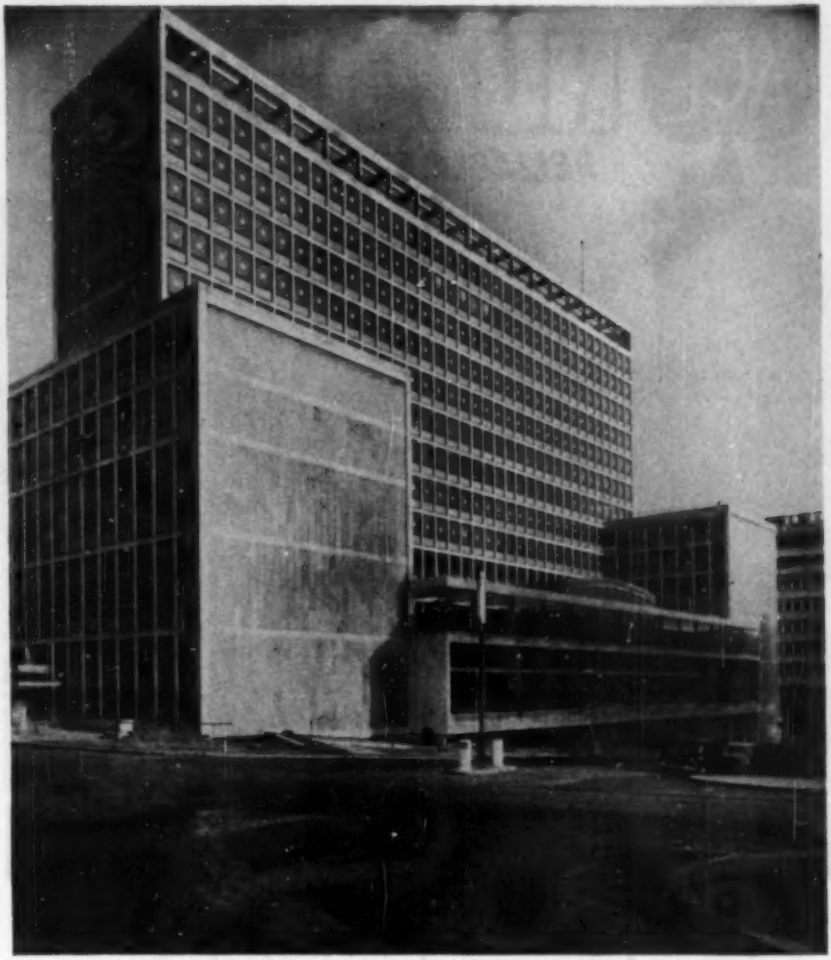

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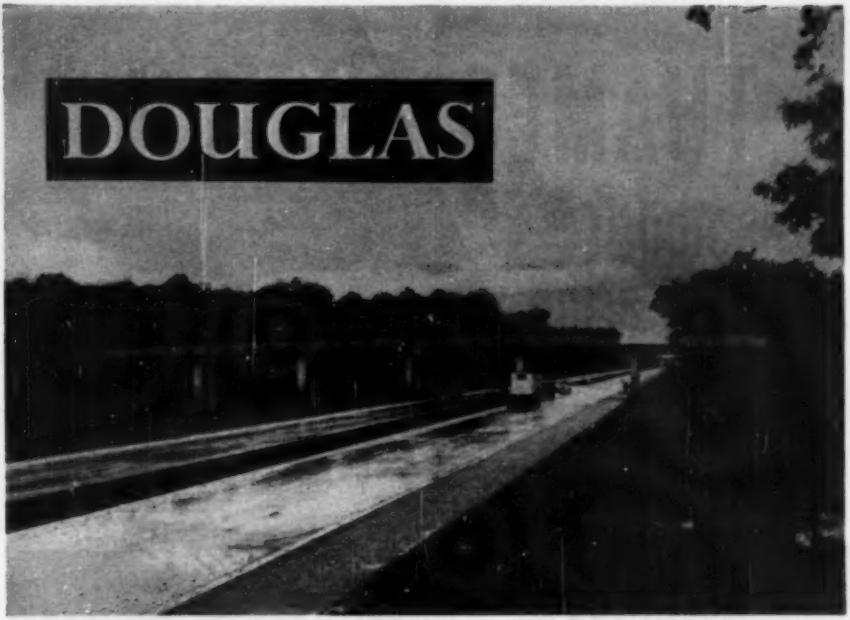

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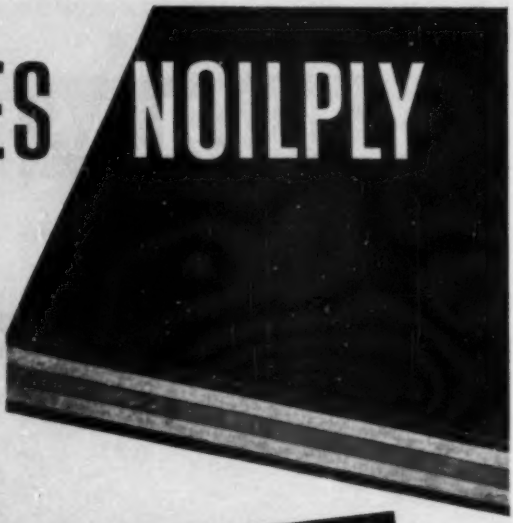

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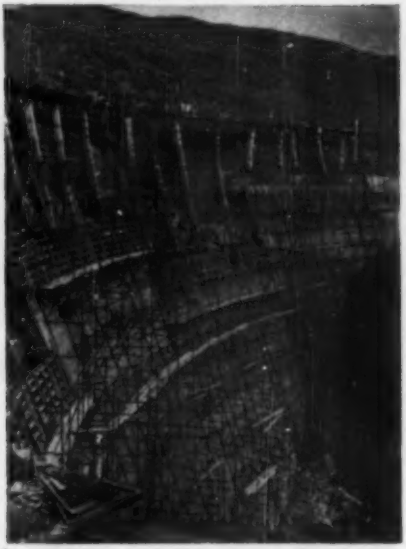

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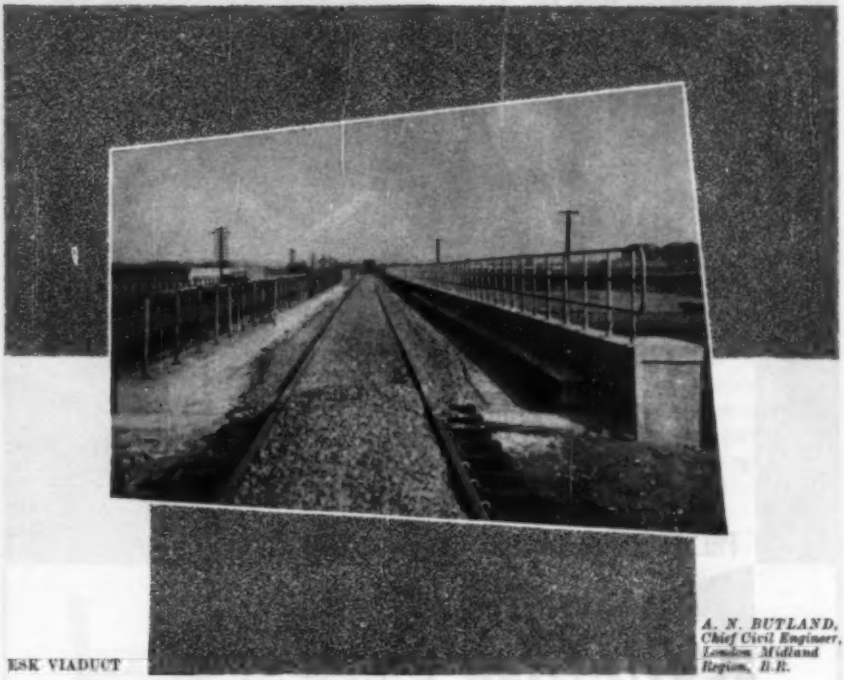

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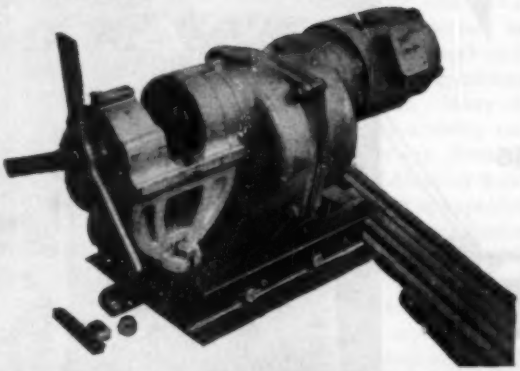

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CONCRETE AND CONSTRUCTIONAL ENGINEERING

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Volume LVI, No. 1. LONDON, JANUARY, 1961.

EDITORIAL NOTES

Roads and Railways.

A FEATURE of civil engineering in Great Britain during the past few years, and in 1960 and currently in particular, is the intense activity on the construction and reconstruction of roads and the modernisation of railways. The conflict, which has persisted for a century and a quarter, between these two primary modes of transport, and more recently between them and internal air services and, to a much less extent, between them and coastal and inland waterways, does not seem yet to be resolved even under nationalisation. The improvement of existing roads and railways and the construction of new motorways, so that each mode shall be better able to play the part for which it is most fitted, has given civil engineers, and concrete engineers in particular, work which is considerable in volume and in interest. Some of these road and railway works, and notably the improvements being made to that long-established main artery, the Great North Road, are described in this number. Many of the road-works are additional to the motorways, the constructional activity on which is noteworthy. The connection between the existing motorway, from the north of London to a point near Rugby, and that at Preston and Lancaster is proceeding in so far that work is in hand on the Staffordshire section and is expected to start soon on the section from near Chester to Preston. Among other schemes the Ross motorway and the Maidstone by-pass are now in use; it is of interest to observe that the Maidstone by-pass is a part, albeit an extremely modest part, of an ambitious scheme to construct international highways from London to Istanbul and elsewhere. Other schemes like the Medway Towns motorway, the Chiswick-to-Langley section of the London-to-South Wales motorway and the Maidenhead by-pass, and the remainder of the Yorkshire motorway from near Rugby to a connection with the Doncaster by-pass are either about to start or are in various stages of construction. In addition, and unrelated directly to these motorways, is the construction of the new bridges over the rivers Forth, Severn and Tamar.

These road-works and the extensive works on the railways are producing civil engineering activities which are likely to continue through the next few years and are of a degree that is probably unparalleled since the heyday of railway construction in the nineteenth century, or of canal building in the previous era.

These works include the construction or reconstruction of hundreds of bridges for which concrete in the form of either reinforced or prestressed construction is the most common material for all but very long spans, although some railway bridges incorporate steel girders with concrete decks. The prominent part played by concrete in railway construction in the middle of the present century is remarkable because it must seem, to the older generation of engineers at least, that only a short time ago reinforced concrete, and later prestressed concrete, was not looked upon favourably by railway engineers in Great Britain. The effect of impact and vibration on concrete was the bogey. But railway engineers have now followed the trend of their colleagues in other fields and consideration of the amount and diversification of concrete works in the modernisation schemes of British Railways removes any doubt regarding the suitability of this material for railway works even in the case of under-line bridges.

The position of concrete in the construction of main roads is rather different, however, since cement-bound granular material (that is "dry-lean" concrete of about 1 : 18 mixture) seems to be becoming the standard material; few of the new motorways are of reinforced or plain concrete of ordinary proportions. So much is this the case, that the Road Research Laboratory has published recently a guide * to the structural design of these so-called flexible pavings. Previous guidance to this form of construction has been restricted to roads on housing estates but the new guide is for main roads including motorways. Particulars are given also for the design of concrete pavings and it is interesting to compare the alternative structural requirements for a road carrying, say, 2500 commercial vehicles daily. On normal ground, a 9-in. slab of ordinary dense concrete reinforced with 5½ lb. of reinforcement fabric per square yard is required, this slab being laid on a 3-in. base slab. The equivalent flexible paving on the same ground comprises a sub-base 6 in. thick under a main base 8 in. thick, which is surfaced with a 4-in. layer of bituminous material laid in two courses; the sub-base and main base are of cement-bound granular materials.

The current constructional activity, especially in respect to the earthworks for the motorways and by-passes, disfigures the countryside. Experience seems to show, however, that such scars may be only temporary. Just as the earthworks of the railways in the past became assimilated into the rural scene, so it is hoped, and there is a good basis for such expectation, that the new roads will be integrated likewise. It is of some importance that the æsthetics as well as the purely engineering planning of a road are given consideration, not only so that the new works do not disfigure the landscape but also so that the amenities are visible to the user. Many factors, important among which are the vertical and horizontal alignments of the road, effect the amenities, and the correctness of these factors is also in general an aid to safety. Many of the precepts governing the pleasantness and safety of roads are self-evident, but that, upon occasion, they require restatement is equally evident from the fact that numerous instances of defective planning exist. Examples of many defects are described in a new book ** which constitutes a guide to the avoidance of such defects.

With so much work of such magnitude proceeding, it is natural to enquire how planning and construction in this country compare with similar activities

* "A Guide to the Structural Design of Flexible and Rigid Pavements for New Roads." Road Note No. 29. Department of Scientific and Industrial Research. (London: H.M.S.O. 1960. Price 2s.)
** "The Landscape of Roads." By Sylvia Crowe. (London: The Architectural Press. 1960. Price 18s. 6d.)

elsewhere. Some opportunity of making such a comparison occurred recently when a party of engineers, under the auspices of the Cement and Concrete Association, visited the U.S.A., and subsequently when engineers from Austria and France gave lectures dealing with the motorways in their countries. As in this country, concrete is used extensively in the construction of road bridges in the U.S.A., although in those parts where steel is readily available composite steel-and-concrete construction is common. It is reported that, except perhaps in California, the use of prestressed concrete was not so advanced as in Great Britain. It is also common in America for complete drawings and details of all requirements to be given to the contractor before he starts work on the site, and thereafter no changes are entertained. For the new motorways in France, of which about a thousand miles are planned but less than a hundred miles are open or in course of construction, reinforced concrete pavings 10 in. thick seem to be the rule. Most bridges in France are of ordinary reinforced concrete but some notable prestressed concrete structures are being erected.

At one time the roads in Great Britain were acclaimed the best in the world but this pre-eminent position seems to have been lost in the 1920's, when German and American, and later Italian, roads were held up as examples of what could be done and what we should be doing to improve our network of highways. Some improvements were made but by no means was the work fast enough to accommodate the growing volume of traffic. Arising from the visit to the U.S.A., the opinion was expressed that technical knowledge and ability in this country are not inferior to that in America, but that in Britain there is not the same sense of urgency in respect to road-works as prevails in the U.S.A. This is a matter which it is hoped will be, or is being, corrected. Reports issued recently by the Roads Campaign Council suggest that the present and proposed rate of construction is not sufficient to keep pace with the continual increase of traffic. It appears that the reason for such disparity is lack of money, and is certainly not the lack of capacity of the civil engineering industry.

Queen's Bridge, Perth.

THE new bridge over the River Tay at Perth, the construction of which was described in the number of this journal for August 1960, was completed during last autumn and was opened by Her Majesty Queen Elizabeth in October.

The bridge is a prestressed concrete structure of three spans.

The consulting engineers are Messrs. F. A. Macdonald & Partners, and the general contractors were Messrs. Whatlings, Ltd.

Book Reviews.

"The Production of Non-metallic Aggregates for Concrete." By L. P. Ratkovskii. (Moscow: Gosstroiizdat. In Russian. 201 pages. Price 6 r. 40 k.; about 11s. 6d.)

THIS book deals fully with the winning and treatment of minerals used as aggregate for making concrete in the U.S.S.R. The importance of the industry is illustrated by the fact that in 1958 the cost of aggregates accounted for 21 per cent. of the expenditure on building materials, this being equivalent to 11 per cent. of the total constructional costs and exceeding the amount spent on wood, bricks, cement and steel. In 1958 nearly 300,000,000 cu. yd.* of aggregate were produced. All aspects of aggregate production are dealt with in twelve chapters from operations at the pit to crushing, grading and storing. The plant and equipment used are illustrated. The contents are as follows. Basic requirements of quality; raw materials; exploitation of pits; the production of ballast; the production of gravel and sand; basic crushing and trading plant; sectional and portable equipment; bins and stores; types and capacity of businesses producing aggregates; safety and sanitation; the production of aggregate abroad; ways to expand production.

[*According to the Sand and Gravel Association of Great Britain, about 70,000,000 tons of sand and gravel are used annually in building and other forms of construction in this country.—ED.]

"Ermittlung Eingeschränkt Plastischer Verformungen im Sand unter Flachfundamenten." By H. U. Smoltczyk. (Berlin: Wilhelm Ernst & Sohn. 1960. Price 16.80 D.M.)

THIS thesis describes the determination of confined plastic deformations in sand under slab foundations. The stresses produced by a slab subjected to an inclined load are determined and used to demonstrate that a calculation more accurate than that commonly used cannot account for the discrepancy between experience and theory. An analytical method is developed for calculating correctly the displacement of the soil by a slab foundation. The investigations show that greater bearing pressures, dependent on the permissible rate of penetration, can be used. However, a great amount of numerical labour is required to obtain a solution and so far no practical application of the method has been made. The interest in the paper is its incentive to further study.

"Tafeln fur Hydrostatisch Belastete Rechteckplatten." By F. Czerny. (Berlin: Wilhelm Ernst & Sohn. 1959. Price 20.80 D.M.)

THIS book in the German language deals with the analysis of rectangular slabs supported on four sides and subjected to loads distributed triangularly. The calculations are based upon Kirchhoff's theory, assuming the slab to be homogeneous and isotropic, and to conform to Hooke's Law. The derivation of the differential equations and evaluation of constants for slabs where one, two, three or all four sides are restrained occupies the major part of the book.

Tables are given which, neglecting Poisson's ratio, show the maximum values of bending moments at the middle and corners, shearing forces, and reactions for slabs having ratios of breadth to length from unity to two.

"Building Technicians' Pocket Diary 1961." (London: Association of Building Technicians. Price 6s. 6d.)

THIS diary, which is now in its fortieth edition, includes about 150 pages of useful information and data on measuring, planning, structural engineering, specifications and legislation, with numerous mathematical tables and a directory of professional and other bodies, technical periodicals, district surveyors, and the like. Upwards of twenty pages relate to concrete, reinforced concrete and allied subjects.

Books Received.

"The Fifteen Wonders of the World." By René Poirier. Translation by M. Crosland. (London: Victor Gollancz Ltd. 1960. Price 25s.)

In addition to some works of the ancients and some works of the 19th and early 20th centuries, the author includes descriptions of the Volga and Tennessee hydro-electric dams and other modern works.

"Constructional Steelwork Simply Explained." By Oscar Faber. Fourth edition revised by John Faber. (London: Oxford University Press. 1960. Price 16s. 6d.)

"Erecting Structural Steel." By S. P. Oppenheimer. (London: McGraw-Hill Publishing Co., Ltd. 1960. Price 74s.)

Improvements on the Great North Road.

MANY works for the improvement of the main road A1, the Great North Road from London to Scotland via Yorkshire, are in the course of construction or have been completed recently. The works incorporate several interesting concrete structures, particularly bridges some of which are described in the following. With the exception of the Doncaster by-pass, the new works are not associated with the proposed motorway from London to Yorkshire, the construction of the first part of which was described in this journal for October and December 1959.

I.—WORKS IN YORKSHIRE.

Doncaster By-pass.

The length of the Doncaster by-pass from the county boundary of Yorkshire northwards is 12¼ miles. In this section there are twenty-eight bridges, the largest being the viaduct over the River Don which is described in this journal for August 1960. In general there are five standard types of bridges, namely four-span bridges carrying existing roads over the road, single-span bridges carrying the road over existing roads, footbridges, culverts and subways, and railway bridges. There are also three two-span bridges in the Warmsworth area carrying existing roads over the new road. The appearance of the bridges was given careful consideration, and the designs were approved by the Royal Fine Art Commission. Because of mining subsidence, continuous structures are inadmissible and only structures with freely-supported spans are provided and these have facilities for jacking.

Fig. 1.—Piers of a Bridge on the Doncaster By-pass.

OVERBRIDGES.—The four-span bridges carrying roads over the new road each comprise three piers and a pair of skeleton abutments where the ground is soft (*Fig.* 1) or bank-seatings if on rock. The piers are slim, tapering from 2 ft. 6 in. at the top to 1 ft. 6 in. at ground level, with battered faces and splayed ends. The central piers are rigid and the side piers are hinged by means of a dowelled joint at the bottom, and are lightly reinforced. Generally the piers are shuttered for their full height and concreted in one operation above the foundations, which are simple spread-footings. The decks are formed with prestressed concrete I-beams with pre-tensioned steel. These beams are brought to the site by road and lifted directly from the vehicles to their positions in the deck. They have bottom flanges wider than the top flanges and a reinforced concrete slab is cast in place after the erection of the beams. The deck is thus hollow and is stiffened by cast-insitu concrete transverse diaphragms through which pass post tensioned cables.

UNDERBRIDGES.—Reinforced concrete is used for the abutments of the single-span bridges carrying the new road over existing secondary roads, the same type of counterforted abutment (*Fig.* 2) being adopted in all cases. This type has triangular-shaped wing walls which are cantilevered from the abutment walls, thereby avoiding the effects of differential settlement. The heights of the abutments are in general on the economic border-line between counterforted and cantilevered types, but counterforts have been adopted as they add to the stiffness of the structure. The abutments have

Fig. 2.

a longitudinal joint near the centre-line of the road. In some instances the abutments have been shuttered and concreted as one unit (*Fig.* 3), but the counterforts form a complicated structure and in some cases the more usual lifting panels of shuttering have been used. Some abutments have an imitation rock-faced surface (*Fig.* 4) which is produced by lining the shutters with sheets of plastic, which were drawn down on to a former by a vacuum process and then backed with lightweight filling to maintain their shape. This treatment gives a rough block-work effect (*Fig.* 5), and when viewed from a short distance the marks of construction joints, bolt holes, and joints in the shutter lining are masked.

The decks of the underbridges are of two types. For two bridges having spans of about 30 ft., prestressed inverted tee-beams with pretensioned steel are used with cast-insitu reinforced concrete filling. Where the span of a bridge is from about 55 ft. to 80 ft., tee-beams with post-tensioned steel and with diaphragms cast on are used (*Fig.* 6). The top flange forms the deck slab. The entire deck is prestressed transversely by means of post-tensioned wires passing through the diaphragms and slab. The fascia beams are rectangular. Longitudinal and transverse prestressing is by the Gifford-Udall-CCL systems.

FOOTBRIDGES.—The two footbridges are each of three spans formed by slender cast-insitu concrete cantilevers with suspended spans between.

The remaining three two-span bridges are in steep rock cuttings, and the abutments are of concrete dowelled to the vertical face of the rock.

Rubber bearings are provided in general as they are cheap, simple to fix, and replaceable.

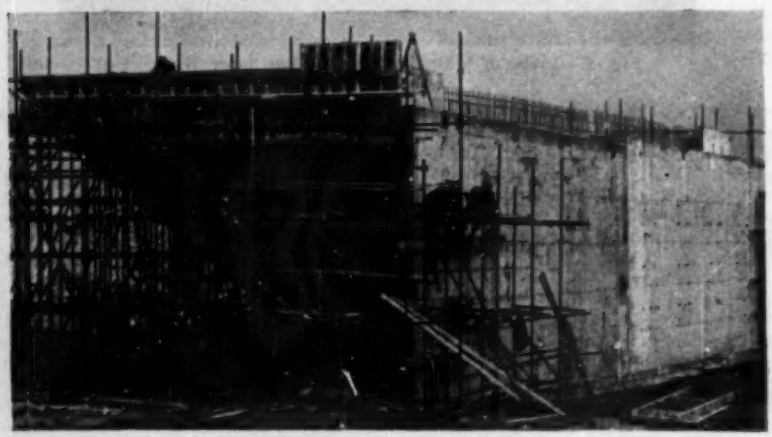


Fig. 3.

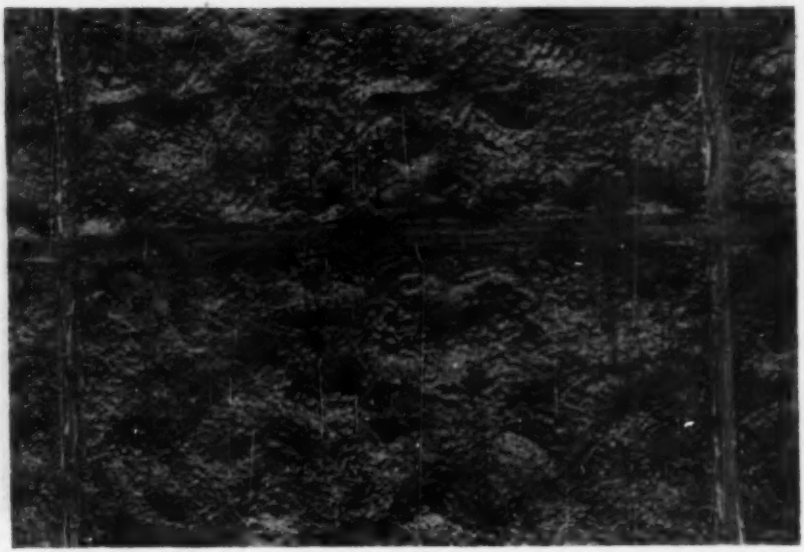


Fig. 4.

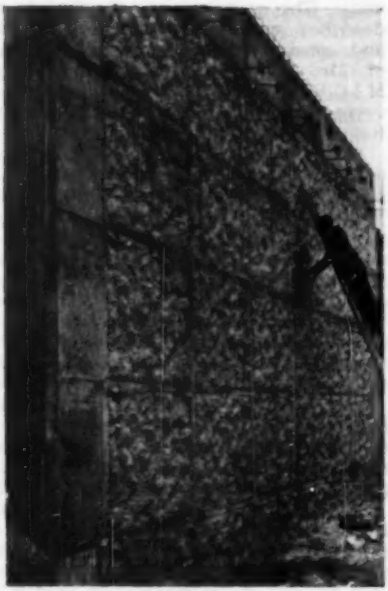


Fig. 5.

A simple type of expansion joint is incorporated in the bridge decks and comprises a tee-shaped bar covered by an aluminium plate over which the surfacing material is placed. The waterproofing membrane of copper-lined bitumen is continuous over the joints, and results in a smooth-running surface free from transverse joints.

A standard type of parapet comprises posts of rolled steel sections and hollow horizontal rails. The posts are set in standard precast concrete parapet blocks cantilevered from the facing beams and forming a feature of the elevation.

Railway Bridges.—There are three bridges with steel decks carrying railways over the new road, and two bridges with concrete decks carrying the road over railways. Construction of these bridges required sheet-pile retaining walls to enable each pier and abutment to be excavated and built separately under a temporary bridge of heavy steel beams. Single spans of the permanent deck were assembled on trestles alongside their final position, the concrete floor was cast (the concrete being pumped), the waterproofing, ballast and tracks were laid, and the complete span of deck rolled into

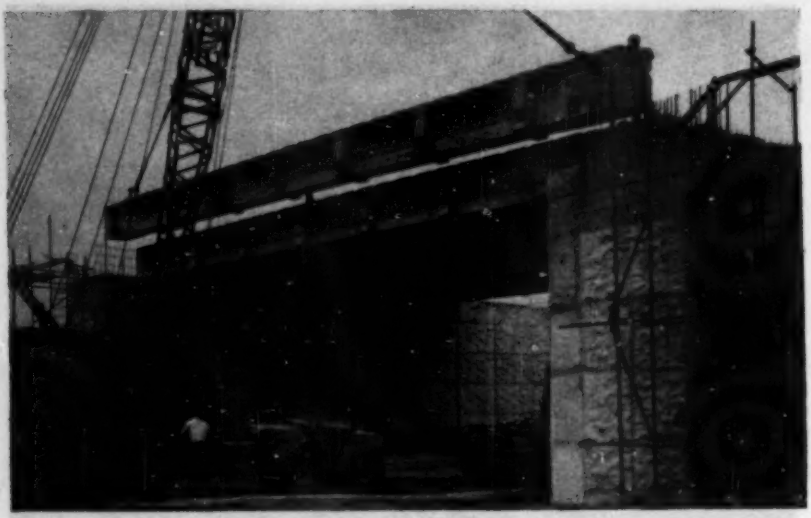


Fig. 6.

position as soon as the supporting structures were complete.

Some of the largest precast beams are incorporated in Reservoir Bridge, which carries the road over a railway in a deep rock cutting. The beams are tee-beams about 90 ft. in length and each weighs about 60 tons. They are supported on concrete bank-seatings set in the rock.

In the bridges, the total length of prestressed concrete beams is 32,000 ft. There are also 700 miles of prestressing steel wire, 29,000 cu. yd. of cast-insitu concrete, and 2100 tons of mild steel reinforcement.

The section of the Doncaster by-pass in Yorkshire is designed by and is being constructed under the supervision of the County Council of the West Riding of Yorkshire acting as agents for the Ministry of Transport. The contractors are a consortium comprising Messrs. Holland & Hannen and Cubitts (Gt. Britain), Ltd., Messrs. Fitzpatrick & Son (Contractors), Ltd., and Messrs. Lehane, Mackenzie & Shand, Ltd.

Other Works in the West Riding.

A considerable amount of work is in hand in connection with the improvement of the original Great North Road within the West Riding of Yorkshire north of Redhouse where the Doncaster by-pass ends. The works, some of which are described in the following, are designed and constructed under the supervision of Mr. S. Maynard Lovell, O.B.E., M.I.C.E., the County Engineer and Surveyor to the County Council of the West Riding of Yorkshire.

HUMBER HEAD BRIDGE.—The improvements on 4¼ miles of the Great North Road from Redhouse to the new Wentbridge by-pass include the reconstruction of Humber Head Bridge over a double-line of railway. The square span is 27 ft. and the width is 81 ft. The deck comprises precast beams with pretensioned steel and a cast-insitu reinforced concrete slab, and is supported on reinforced concrete abutments the walls of which are founded on bored piles of 19-in. diameter. Adjacent to the bridge is an existing culvert which is being extended on the western side in reinforced concrete and is supported partly on bored piles and partly on precast piles.

On the eastern side of the approach to the bridge, which is being constructed in two sections, there is a retaining wall of plain concrete. The wall contains 3000 cu. yd. of concrete and is 1200 ft. long, 7 ft. thick at the top of the base,

Fig. 7.—Micklefield Bridge.

and has a total height of 15 ft. generally. Panels of steel shuttering were used.

The contractors are Messrs. George Wimpey & Co., Ltd.

WENTBRIDGE VIADUCT AND WENT EDGE ROAD BRIDGE.—The Wentbridge by-pass will be 1·85 miles in length and will cross the River Went by a viaduct. The structure, which will be 470 ft. long and 78 ft. wide with the deck 96 ft. above the river, is to comprise prestressed concrete box-girders continuous over three spans. The outer supports are reinforced concrete skeleton abutments and the intermediate supports will be raking legs, which will be hinged at the top and bottom, the bases being blocks of plain concrete. The end spans will each be 140 ft. long and the central span will be 190 ft. long. At one end-support the girders will be freely supported and at the other end-support they will be fixed, but only after prestressing is completed. The girders, which are to be constructed insitu, will be prestressed with post-tensioned 1¼-in. strand, with additional cables over the supports and vertical cables at positions where the shearing force is greatest. The abutments, which are in course of construction, are being concreted by the use of two 4-in. pumps for each abutment. The centering for the superstructure will be of Bailey-bridge construction supported on bored piles, the working load on each of which will be 90 tons; the piles will be 20 ft. deep on the northern bank and 40 ft. deep on the southern bank.

The existing Went Edge Road will cross the new road by a bridge of 80-ft. span and 36 ft. wide. The deck is of prestressed beams with a cast-insitu slab and is supported on reinforced concrete abutments.

The contractors for the Wentbridge by-pass are Messrs. Taylor Woodrow Construction, Ltd.

BROTHERTON BY-PASS.—The bridges on the Brotherton by-pass, which is a mile in length, will include a skew bridge over a double-line of railway, two over-bridges, and a footbridge. There will also be four reinforced concrete culverts, the top and bottom slabs of which will be 2 ft. thick. The deck of the railway bridge, which will have a square span of 28 ft. and a width of 81 ft., will comprise steel beams and a concrete slab, and will be supported on abutments, with wing-walls, of plain concrete with brick facing. The abutments, for the construction of which ready-mixed concrete is being used, are supported on bored piles taken down to rock; where rock is not at a reasonable depth, inclined piles are provided.

The contractors are Harbour & General Works, Ltd. The sub-contractors for the piling are the Cementation Co., Ltd.

MICKLEFIELD RAILWAY BRIDGE.—The Micklefield by-pass, which is about 1¼ miles long, crosses a railway by means of a prestressed concrete bridge (*Fig.* 7). The longitudinal prestressed precast beams are 68 ft. long and were brought up to the site by rail and were lifted off the railway wagons and deposited directly into position in the structure. The two parapet beams contain ducts and are also precast, the precast covers being brought to the site by road and erected

Fig. 8.—Wharfe Bridge, Wetherby.

by a mobile crane. The finish of the exposed faces of the parapet beams is bush-hammering, the faces being subsequently coated with a silicone paint. The concrete deck slab was cast in place. The abutments are of reinforced concrete with cantilevered wing walls. The concrete for the deck slab and abutments was prepared in a twin-batching and mixing plant in which the concrete for the marginal strips alongside the new road was also mixed, and was transported therefrom in lorries.

The contractors were Pa.ior Construction Co., Ltd. The precast beams were supplied and erected by Kingsbury Concrete Co., Ltd.

WHARFE BRIDGE, WETHERBY.—The bridge, which carries the Wetherby bypass over the River Wharfe, was completed in October 1959 and is a three-span structure (*Fig.* 8) comprising two side spans each 96 ft. long and a 160-ft. central span made up of two cantilevers each 45 ft. long and a suspended span 70 ft. long. The bridge is on a skew of 13 deg. The two sets of eight parallel beams composing the side spans and cantilevers are of cast-insitu reinforced concrete, as is also the 12-in. deck slab. The balanced-cantilever beams are 4 ft. wide and about 17 ft. deep at the piers, 6 ft. at mid-span, and 8 ft. at the outer ends. They are fixed in position at the piers but are free to rotate. The suspended span is composed of two reinforced concrete rectangular fascia beams and fifteen prestressed precast I-beams 5 ft. 3 in. deep with post-tensioned 0·276-in. wires. After erection of the precast beams, transverse diaphragms were cast insitu and the assembly was prestressed transversely.

The abutments and wing walls are of plain concrete on a rock foundation and, where exposed, are faced with squared snecked rubble masonry. The two piers are also of plain concrete with a tooled finish; the face of the concrete had previously been left with a textured surface provided by plastic lining in the shuttering. The aggregates are quartzite gravels obtained from one source to avoid differences of colour; care was taken in the selection of the aggregate to obtain an appearance after tooling which would blend with the stone of the district. The exposed faces of the piers and fascia beams were given a silicone treatment.

The centering for the cantilevers, which was built on a staging of steel beams supported on 12-in. square timber piles, consisted of steel scaffolding carrying timber bearers for the soffit shutters. The centering for the side spans was of similar construction except that timber piles were only used to support the scaffolding over the low ground adjacent to the piers; over the remaining area the steel scaffolding was supported on concrete foundations, and on the higher ground near the abutments on timber sleepers. Erection of the precast beams was carried out by means of a temporary launching girder, which was placed in the correct line for each beam. The beam was then carried out on bogies and jacked down into its final position after removing the launching girder sideways.

The main beams are supported at each abutment on mild steel rocker-bearings, 17 in. in diameter, 3½ in. thick, and 3 ft. 8 in. long, housed in prefabricated mild steel boxes set into the concrete abutments. The boxes are filled with soft bitumen to prevent corrosion but allow movement due to change of temperature. The suspended beams are

each supported at the fixed end by a pair of 2-in. mild steel plates, the lower plate being convex and fitted with a locating key. At the expansion end the beams are supported on mild steel rocker-bearings, 24 in. in diameter, 3¼ in. thick and 11 in. long. Three expansion joints are provided, one at each abutment and one at the free end of the suspended span.

The bridge is designed so that there is a permanent downward force at the abutments under working loads, but for ultimate-load conditions there may be an upward force which is resisted by 2-in. diameter mild steel eyebolts dowelled into the concrete of the abutments but which are free to move as the structure expands or contracts.

The main contractors for the by-pass were Messrs. Crowley, Russell & Co., Ltd., the sub-contractors for the bridge being Cementation Co., Ltd. The prestressing is by the Gifford-Udall system.

WALSHFORD BRIDGE.—The bridge over the River Nidd at Walshford has been widened from 60 ft. to 81 ft. The structure is an open-spandrel reinforced concrete arch bridge, the skew span of which is 101 ft. The old bridge comprises five arch ribs and the new work comprises two similar ribs. The abutments are carried on raking and vertical precast concrete piles. The contractors were Messrs. Crowley, Russell & Co., Ltd.

Other works in progress in the West Riding include the Aberford by-pass which will require a fly-over junction and one other bridge.

(To be concluded.)

An Office Building at Shepherd's Bush.

THE construction of an eight-storey building (*Fig.* 1), showrooms and a demonstration theatre was completed for the London Electricity Board early last year. The structural frame is of cast-insitu reinforced concrete. The multiple-storey block has piled foundations. Cantilevered foundations are provided for the showrooms and theatre because of the proximity of adjoining buildings. The two new buildings are separated by a structure-joint.

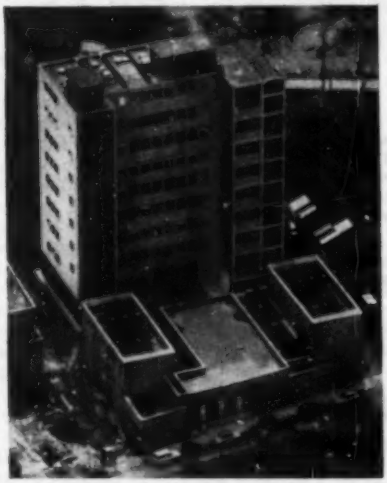


Fig. 1.—Office Building, Shepherd's Bush.

Each floor of the main block comprises 30-in. by 10-in. main beams spanning 23 ft. 6 in. and cantilevering 5 ft. at each end. The cantilevers are pierced by a 24-in. by 15-in. opening, for services, close to the supporting columns. Longitudinal tie-action is provided in the slab at the columns and the wind forces are transmitted to the two frames at each end of the main floor by means of a slab 5½ in. thick. The building is 103 ft. long and 33 ft. 6 in. wide; the stair structures are outside this width. The main stair is approximately elliptical on plan and, to avoid unsightly beams at the commencement of each flight, the stairs are supported on a 9-in. slab and have a 7-in. waist.

The architects are Messrs. Stanley Peach & Partners and the consulting engineers are Messrs. Walter C. Andrews & Partners. The contractors are Messrs. Killby & Gayford, Ltd.

Fig. 1.—Bridstow Bridge.

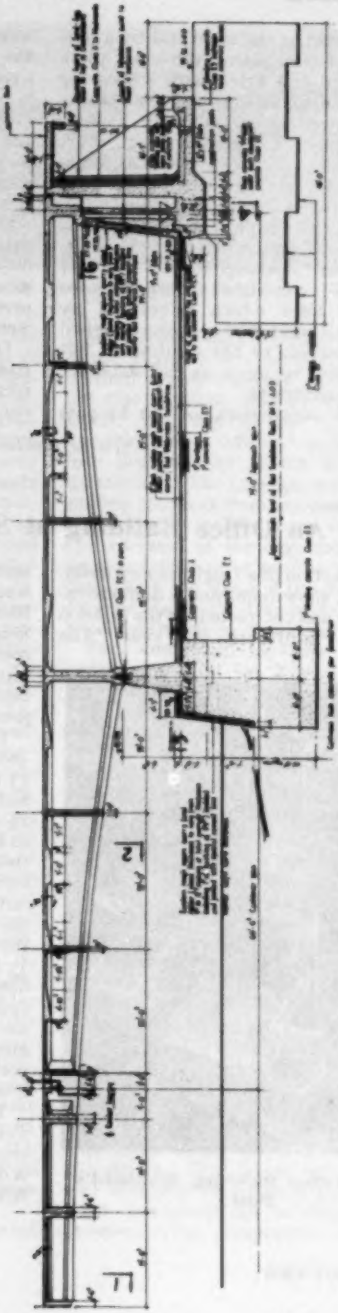


Fig. 2.—Bridstow Bridge: Part Longitudinal Section.

(See facing page.)

Bridges on the Ross Motorway.

THE new road which was recently opened from near Tewkesbury, Worcestershire, through part of Gloucestershire to near Ross-on-Wye, Herefordshire, and which is called the Ross motorway, is 22½ miles long, including the 1½ miles of the Ross by-pass. There are forty-one bridges, the two principal structures being the bridge over the River Wye at Bridstow and the Queenhill Bridge over the River Severn.

The construction of the central spans of the Queenhill Bridge are steel girders continuous over three spans, two being each 130 ft. long and the middle span being 240 ft. long. The approach viaducts are of reinforced concrete and comprise fifteen spans on the eastern side and nine spans on the west, each span being 84 ft. long; each carriageway is carried on cellular tee-beams which are supported on a line of columns. The piers are supported on steel caissons which were sunk by compressed air and which are founded on marl at depths from 28 ft. to 47 ft. below ground. The total length of the structure is 2466 ft. The consulting engineers are Sir Alexander Gibb & Partners, the consulting architects being Sir William Holford & Partners. The contractors are Messrs. A. E. Farr, Ltd.

Other concrete bridges on the motorway include a segmental reinforced concrete arch over-bridge of 90 ft. span with masonry facing to the spandrel walls; an under-bridge with a prestressed precast concrete deck; a portal-frame underbridge of 54 ft. span; a two-span overbridge of the hollow-slab type seated on rubber bearings; a cantilever and suspended span under-bridge over 100 ft. long; and a beam-and-slab over-bridge continuous over two 41-ft. spans.

Adjacent to Bridstow Bridge there is a small two-span portal-frame bridge which carries the Ross by-pass over a railway and a road; the central pier and haunches are bush-hammered.

Bridstow Bridge.

The Bridstow Bridge (*Figs.* 1 and 2), the construction of which was completed in September last year, comprises three spans, the central span being of the cantilever-suspended beam type. The overall length is 353 ft. and the overall width 79 ft. 6 in. The clear span over the river is 203 ft. and comprises two cantilevers each 66 ft. 6 in. long supporting a central suspended beam 70 ft. long. The bridge is designed to carry the Ministry of Transport standard loading and an abnormal load of 180 tons in accordance with British Standard No. 153.

The foundations of the piers and abutments are of plain concrete bearing on old red sandstone which is found about 15 ft. below the level of the natural ground. The foundations of the piers, which were constructed within steel sheet-pile cofferdams, are continuous along the length of the piers. The abutment foundations, which were constructed in open excavation, are separate bases of plain concrete under each counterfort of the abutment wall and are at about 18-ft. centres. The piers are of reinforced concrete, and embedded in the top of each are the lower parts of steel rocker-bearings, the upper parts being cast into each of the main beams. The ends of the piers are shaped to form cut-waters in order to reduce to a minimum the obstruction to flow of the river in times of flood. The abutments are reinforced concrete counterforted retaining walls. The wing walls are also of the counterforted type and are curved for æsthetic and hydraulic reasons. The abutments and wing walls retain the earth of the approach embankments. The deck of the bridge is isolated from the abutments and is supported on, and held down to, flexible reinforced concrete walls, in front of each of which is a concrete wall nominally reinforced to support the masonry facing.

The side spans and cantilevers of the bridge, which were cast insitu, include nine prestressed concrete beams at about 8-ft. 6-in. centres, each 141 ft. 6 in. long and varying in depth from about 13 ft. over the piers to about 6 ft. at each end. They contain post-tensioned cables each comprising twelve 0·276-in. high-tensile steel wires. The beams support the 8½-in. deck slab which contains longitudinal post-tensioned wires and which acts in conjunction with the beams to form the cantilevers.

The suspended span comprises nine beams, each of which is 70 ft. long and varies in depth from 6 ft. at the ends to 5 ft. at mid-span. Each are prestressed

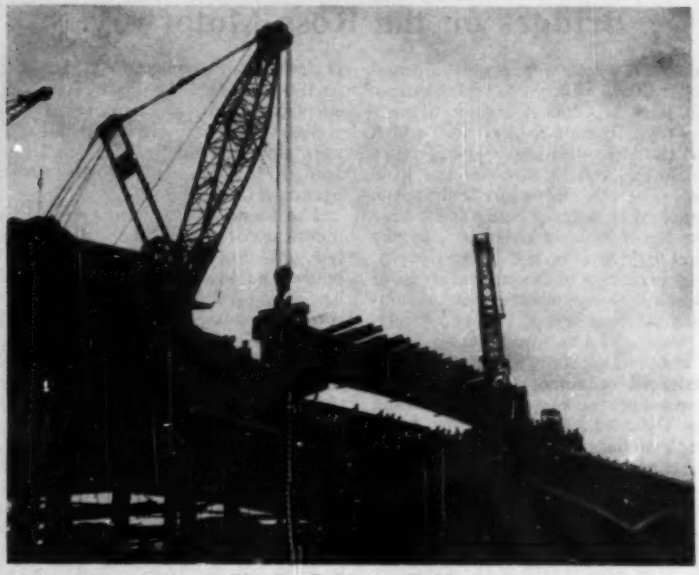


Fig. 3.—Bridstow Bridge.

with post-tensioned cables comprising twelve 0·276-in. wires. The suspended beams, which support an 8-in. reinforced concrete deck slab, weigh 60 tons each and were precast and prestressed near the site of the bridge. The equipment used for placing the beams in position comprised a triple Bailey bridge, a rail-track and bogies, and two lorry-mounted cranes, the use of which greatly speeded the operation. Without the cranes, blocks-and-tackle and jacks would have had to be used and erection would be slow and laborious. A 40-ton lorry-mounted crane remained on the eastern approach to the central span throughout the operation, while a 50-ton crane made several trips from one side to the other, the route, nearly two miles long, being through the town of Ross. One crane first placed the bogies on the rail-track and then both cranes worked together to lift two of the beams on to the bogies. While the 50-ton crane travelled to the western approach the first beam was drawn on to the Bailey bridge by a winch. The two cranes then lifted the beam off the bogies and placed it in position between the cantilevers (*Figs.* 3 and 4). The beam was then secured to the cantilevers by a rocker-bearing at one end and a roller-bearing at the other. The bogies which had carried the first beam were stacked by the 50-ton crane on the western approach, and the second beam was drawn, on its bogies, on to the Bailey bridge from which it was placed in

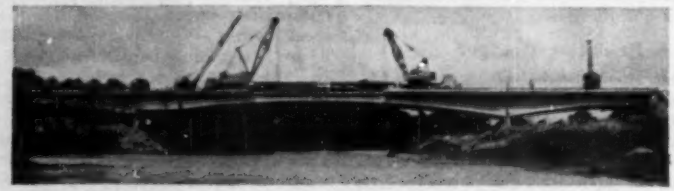


Fig. 4.—Bridstow Bridge in Course of Construction.

position between the cantilevers. All the bogies were then returned to the eastern end of the track to which the 50-ton crane also travelled by road. This operation was repeated with each pair of beams and with the ninth beam. The only interruption in the sequence was to dismantle part of the rail-track and to lift the Bailey bridge from one side of the structure to the other, using the two cranes.

Transverse stiffness is provided by means of reinforced concrete diaphragms at about 20-ft. centres acting in conjunction with the cast-insitu deck slabs. In general the finish of the concrete is fair-faced, but the piers and exposed faces of the webs of the fascia beams are tooled. The abutments, wing walls and the visible sides of the pier foundations are faced with old red sandstone.

The bridge was designed for the Ministry of Transport by Messrs. Scott & Wilson, Kirkpatrick & Partners, who also supervised the construction. The contractors were Tarmac Civil Engineering, Ltd.

Doubly-curved Shell Roofs.

SEVERAL useful papers are given in the Journal of the American Concrete Institute for October, 1960, relating to the design and construction of hyperbolic and elliptical paraboloidal concrete shell roofs, and they include the following.

"General Formulas for Membrane Stresses in Hyperbolic Paraboloidal Shells." By F. Candela. The formulæ apply to a reinforced hyperbolic paraboloidal shell, under the action of its own weight and disposed in an arbitrary position in space. A numerical example of a groined vault, square in plan, is given.

"Building for Economy with Hyperbolic Paraboloids." By G. Madsen and D. Biggs. The design and construction of the hyperbolic paraboloidal shells for the roof of a shopping centre at Minneapolis, U.S.A., is described. The roof is 112 ft. by 132 ft., and 28 ft. high, and the slab is 3 in. thick.

"Hyperbolic Paraboloidal Umbrella Shells under Vertical Loads." By H. P. Harrenstein. Tests of two hyperbolic paraboloidal shells are described. The shells were subjected to concentrated loads and the resulting strains were observed. Stresses corresponding to these strains were determined and the results are presented in the form of stress "contours" for each of nine positions of the load. Methods are described of predicting the stresses in such shells subjected to any loading provided the deflections are small and the stresses are within proportional limits.

"Shell at Denver—Hyperbolic Paraboloidal Structure of Wide Span." By A. Tedesko. The design and construction of a pavilion are described. The roof comprises four hyperbolic paraboloidal shells and is supported on steel hinges on buttresses at the four corners of the roof.

"Experiments with Thin-shell Structural Models." By J. L. Waling and L. B. Greszcuk. A method is proposed of forming hyperbolic paraboloidal slabs on permanent shuttering of "Styrofoam" (plastic planks) which is supported by wires and remains as insulation and a vapour barrier. Experiments on models of various sizes are described.

"Determination of Membrane Stresses in Elliptic Paraboloids using Polynomials." By L. Fischer. A mathematically simple method is given, the differential equations of equilibrium being solved by the introduction of a polynomial expression for the stress function, the coefficients of which are easily determined. The stresses are then determined as derivatives of the stress function. A numerical example is given.

A Centenary.

THE centenary of the firm of Messrs. Sandberg was celebrated last month.

The firm was established as consulting and inspecting engineers in London in 1860 by Mr. Christer Peter Sandberg. For many years the firm specialised in works associated with railways in many parts of the world but, during the last decade, testing and other investigations in connection with concrete have been added to the metallurgical side of the business. Some of the major works in which the firm has had an interest in respect to concrete include the new Forth and Tamar bridges, the Hammersmith fly-over, and the Clatworthy dam.

Reconstruction of a Road-over-rail Bridge at Gateshead.

THE principal factor in the design of the bridge to replace an existing structure by means of which Park Lane, Gateshead, crosses a railway line, was to provide the necessary headroom over the rail tracks combined with least gradient on the approach roads, and therefore a minimum depth of structure was desirable throughout the length of the bridge. By providing cantilevers from the approach-span beams to support the beams of the middle span, rather than providing three dissimilar freely-supported beams, the greatest stresses occurring at the centre of the middle span and at the supports could be equalised.

The length of bridge (*Fig.* 1) is 140 ft. and the width is 74 ft. The structure is on a skew of 16 deg. 13 min. The bridge deck consists of prestressed precast I-beams with a 4-in. cast-insitu slab. The overall depth of the beams, which contain post-tensioned cables, is 2 ft. 8 in. The approach spans are each 30 ft. long. The

Fig. 1.

Fig. 2.

middle span is 80 ft., the central beam of which is 60 ft. long and is supported on the ends of the approach-span beams which cantilever 10 ft. from the inner supports. The deck was prestressed transversely after construction. Each inner support is a reinforced concrete frame in which the columns are raked at an angle of 12 deg. to the vertical and which is founded on 19-in. diameter bored piles. At the outer supports, the ends of the approach-span beams are supported directly on the pile-caps of similar piles.

The bridge was designed for the Borough Engineer of Gateshead, Mr. G. F. Winters, by the British Reinforced Concrete Engineering Co., Ltd. The contractors were Sir Robert McAlpine (North Eastern), Ltd.

Concrete Bridges on British Railways.

THE modernisation and other improvements now proceeding on British Railways result in a considerable amount of civil engineering work. Some bridges, being of particular interest to concrete engineers, are described in the following.

Bletchley Fly-over.

The fly-over (*Fig.* 1) constructed at Bletchley is a reinforced and prestressed concrete viaduct by means of which the Cambridge-to-Oxford line crosses the main line of London Midland Region. The structure comprises several spans with prestressed precast I-beams with flat soffits (*Fig.* 2) and four spans, with curved soffits, over a road and adjacent land. There are thirteen parallel longitudinal beams (*Fig.* 3) in each of the spans with flat soffits; each beam is freely supported and has a sliding bearing at one end and a rocker-bearing at the other. The deck is a cast-insitu reinforced concrete slab and is prestressed transversely.

The four spans with curved soffits comprise a cast-insitu reinforced concrete double-cantilever at the central pier, a beam and cantilever of similar construction extending from the first support to beyond the second support at each end of this series of spans, and precast suspended spans supported on the cantilevers in the second and third spans. The beams are carried on roller-supports at each end support and on rocker-bearings at the two intermediate supports; the double-cantilever is fixed at the central support

The supports generally comprise two rectangular reinforced concrete columns with a cross-head which cantilevers a short distance beyond each column (*Fig.* 2). Where the viaduct crosses the rail-tracks a different arrangement of

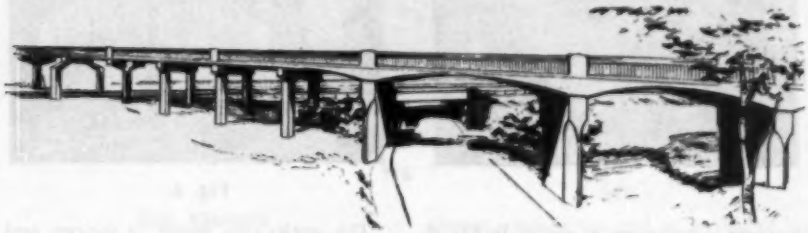


Fig. 1.—Bletchley Fly-over.

Fig. 2.—Bletchley Fly-over.

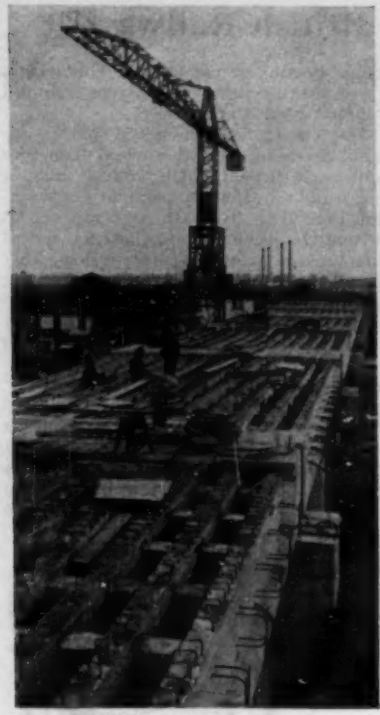


Fig. 3.

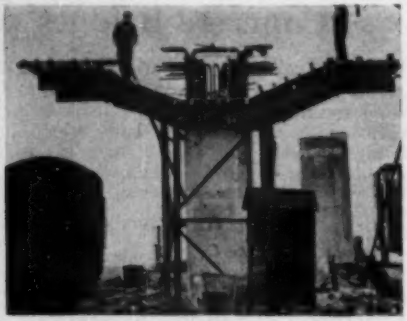


Fig. 4.

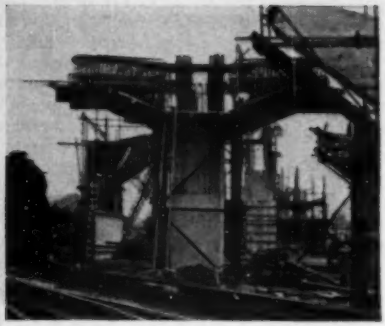


Fig. 5.

supports is necessary as shown in *Fig.* 6, and comprises single and double cantilevers. *Figs.* 4, 5 and 7 show successive stages in the construction of these special supports, for which a steel cantilevered frame was erected first and the timber shuttering was built up thereon.

The works cost about £1,500,000 and are being carried out to the designs of, and under the supervision of, the Chief Civil Engineer of London Midland Region. The contractors are the Demolition & Construction Co., Ltd., and Leonard Fairclough, Ltd.

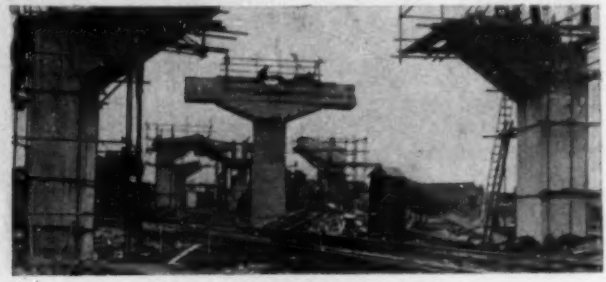


Fig. 6.

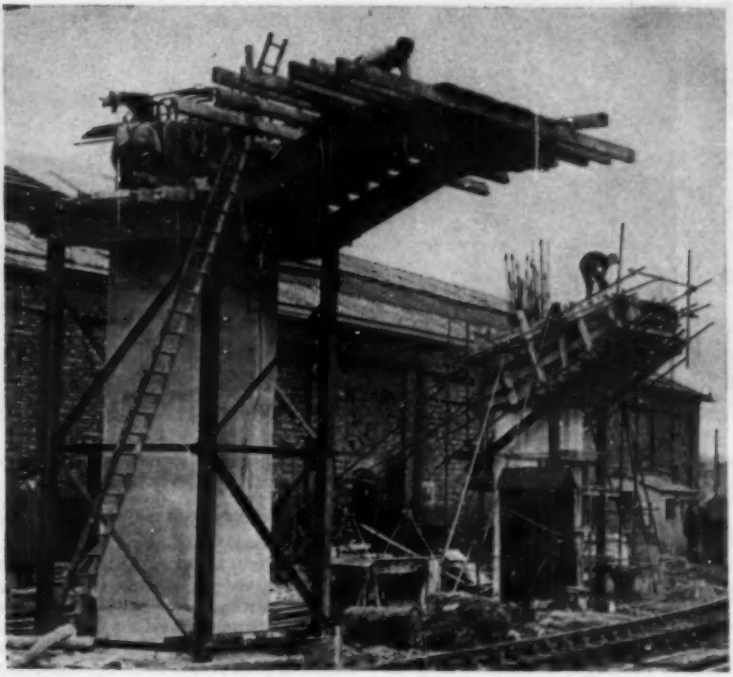


Fig. 7.

Esk Viaduct.

The accompanying illustrations (*Figs.* 8 and 9) show two views of the new viaduct over the River Esk between Floriston and Gretna Junction, about 6¼ miles north of Carlisle, which carries one of the tracks of the main line of the West-coast route to Scotland. The original structure is over 1050 ft. long and has thirty flood openings each spanning 21 ft. and seven river spans each about 40 ft. long. It comprises mainly longitudinal steel girders (with a timber deck) supported on sandstone piers, which were part of an earlier structure built in 1847; the steel girders were placed when the superstructure was reconstructed in 1905.

The River Esk is subject to severe flooding, and at the viaduct it is normally about 270 ft. wide, and there is a tidal range of about 6 ft. During floods the water may reach to the underside of the longitudinal girders. The structure had almost reached the end of its useful life and the piers were rapidly deteriorating. During the winter of 1957–58 serious trouble arose in several piers supporting the river spans, and there was slight settlement of the foundations. Immediate remedial measures had to be taken and it was necessary to reconstruct the river spans first, thus enabling the defective piers to be removed. Following the completion of this work in August 1959, the scheme for the new freight-marshalling yard at Kingmoor was put in hand and required an additional line on the Esk Viaduct, so that in addition to reconstruction, the viaduct was therefore to be widened.

The new structure (*Figs.* 8 and 9), which carries the goods line, has thirty-seven spans, the lengths being 25 ft. for the flood spans and 30 ft. for the river spans. The foundations of the new structure are 19-in. diameter bored piles constructed in

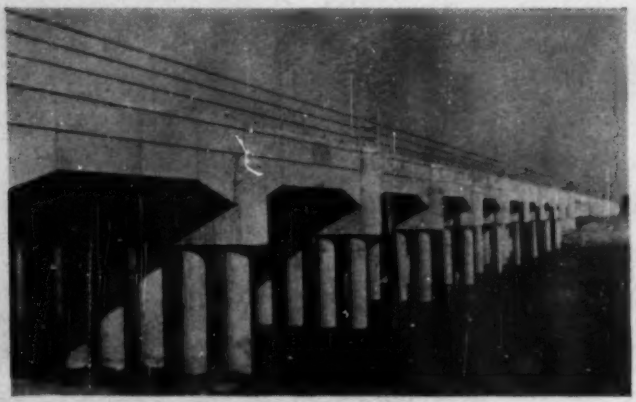


Fig. 8.—Esk Viaduct: River Spans.

rows of twelve and spaced at 4-ft. centres. Each row is surmounted by a cast-insitu reinforced concrete beam. The new piers are between the existing masonry piers and there was therefore no interference with the existing structure. The deck is constructed of inverted prestressed precast tee-beams spanning between the extended piled piers. Reinforced concrete was cast insitu between the precast beams, thus making a monolithic deck on which the ballast and track are laid.

The reconstructed part which will carry the main lines will have reinforced concrete well-decks supported on longitudinal steel girders spanning between the piled piers. Where possible the existing steel longitudinal girders will be modified and re-used. Reconstruction is expected to be complete by May 1961.

The work is being carried out by the railway staff under the direction of Mr. A. N. Butland, Chief Civil Engineer, London Midland Region. The piles were provided by The Cementation Co., Ltd. The prestressed precast tee-beams were supplied by Costain Concrete, Ltd.

Fairfield Street Bridge, Manchester.

An unusual form of railway bridge has been constructed at London Road Station (now Piccadilly), Manchester. The new structure, which carries the railway over Fairfield Street and Carston Street, replaces two former bridges now demolished, and is of prestressed concrete construction with a single skew span of 170 ft. It carries two rail-tracks and supports an island platform.

The deck is a hollow slab 31 ft. wide and 8 ft. thick divided by vertical webs into three longitudinal compartments. In addition to being the main structural member, the slab forms the island platform on which the station buildings are erected. The two tracks are carried on cantilevered slabs 16 ft. wide projecting on both sides from the bottom of the cellular slab. Temporary steel supports were erected to carry the shuttering

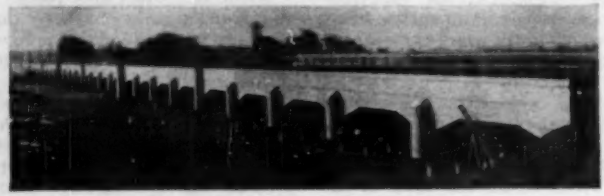


Fig. 9.—Esk Viaduct: Approach Spans.

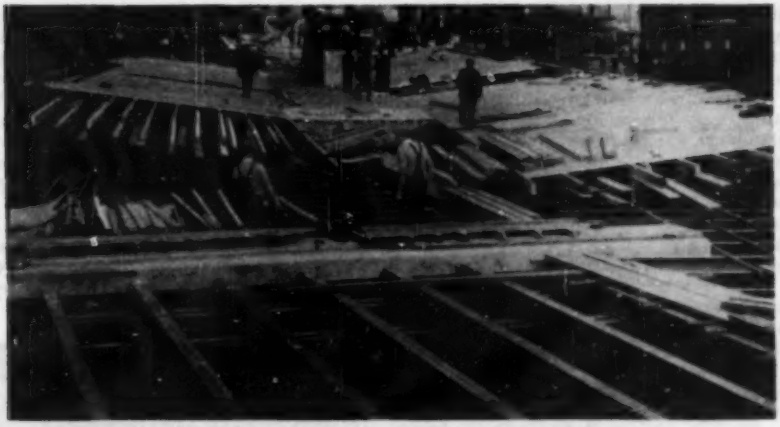


Fig. 10.—Fairfield Street Bridge, Manchester.

(*Fig.* 10) on which the concrete was cast prior to post-tensioning the cables which apply a total compressive force of 12,000 tons. The bottom slab is shown in course of construction in *Fig.* 11. The structure is carried on four supports, two being columns, each of which is designed to support 2500 tons. Details of the reinforcement at the head of one of the columns are given in *Fig.* 12. The other two supports are provided by abutments, the bearings on which being rubber pads allow for longitudinal and rotational movements. Because of the unusual shape of, and loading on, the bridge, a quarter-scale model, which is described briefly in the number of this journal for July 1960, was tested.

The bridge is designed for a total load of 5750 tons. The dead weight of the new structure, excluding the station buildings and rail-tracks, is 3000 tons.

The work was carried out for the London Midland Region, the contractors being Messrs. Leonard Fairclough, Ltd. The designs were prepared by Stressed Concrete Design, Ltd.

Precast Girders 130 ft. Long for Chancellor Lane Bridge.

The reconstructed bridge carrying six rail-tracks over Chancellor Lane, Manchester, is formed of prestressed precast beams of the exceptional length of about 129 ft. 8 in. Each beam (*Fig.* 13) comprises a central span of 63 ft. 10½ in. and two cantilevers each 32 ft. 10½ in. long. The depth at midspan of the central span and at the ends of the cantilevers is 2 ft. 7 in. and at the supports 3 ft. 10½ in. The width is 1 ft. 9½ in. throughout. A noteworthy feature is that the beams, which weigh 45 tons each, were made near Norwich and transported by rail to the

Fig. 11.—Fairfield Street Bridge, Manchester.

site, a distance of nearly two hundred miles; the special arrangement of railway wagons required for the journey is shown in *Fig.* 13.

The beams are prestressed by means of cables post-tensioned by the Magnel-Blaton system, there being one cable containing forty-eight 0·276-in. wires and two cables having sixteen wires in each beam. The largest cable is horizontal throughout the beam. The two smaller cables are curved up over the supports and are in the top of the cantilevers.

Each rail-track is supported by six beams, there being a total of forty intermediate beams and two fascia beams. The bridge is on a skew of 47 deg. 8½ min. A lifting device comprising a steel lattice girder 132 ft. long was designed and made specially for erecting the beams; the device was tested at the works where the beams were made before being sent to the site.

The bridge was designed by the bridge-designing section of London Midland Region. The contractors were Messrs. Leonard Fairclough, Ltd. The beams were made by Anglian Building Products, Ltd.

A Bridge at Gateshead.

Fig. 14 shows the new bridge which carries a railway over a main road at Gateshead. It is a reinforced concrete two-span structure, the longitudinal beams being precast and 36 ft. long. The bridge was designed and erected by the civil engineering department of North Eastern Region and cost £14,000. The precast beams were made by Kingsbury Concrete Co., Ltd.

Barton Old Hall Bridge and Footbridge.

The Barton Old Hall Bridge (*Fig.* 15), which carries the four rail-tracks of the Manchester-to-Liverpool line over the Stretford–Eccles by-pass, is a composite structure comprising welded steel girders supporting a reinforced concrete deck slab, designed to act together. There are two skew spans each of 40 ft. The abutments are of plain concrete with a facing of brickwork. The intermediate support is a reinforced concrete portal frame. There is a small semi-circular arch bridge adjacent to the main bridge.

Alongside the main bridge, there is a prestressed concrete footbridge which is seen in front of the main bridge in *Fig.* 15. The footbridge, which is approached by

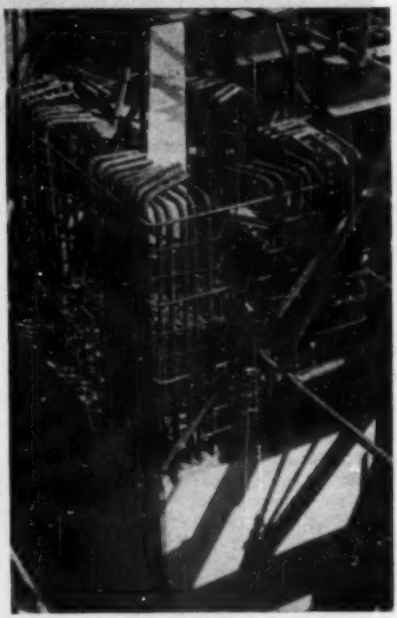


Fig. 12.

Fig. 13.—Girders for Chancellor Lane Bridge.

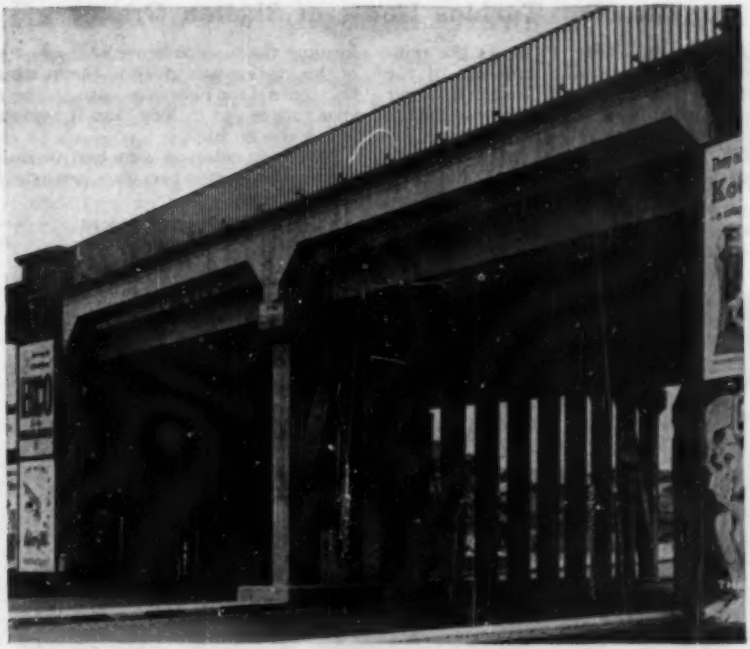


Fig. 14.—A Bridge at Gateshead.

earth ramps, crosses both carriageways of the by-pass in one span of 80 ft.

The cost of the bridges, which were completed in 1959, was about £110,000 including the ramps. The structures were designed and constructed under the supervision of Mr. A. N. Butland, Chief Civil Engineer, London Midland Region. The contractors were Messrs. G. Drew & Co., Ltd.

Fig. 15.—Barton Old Hall Bridge.

The New Turbine House at Skelton Grange.

THE illustration (*Fig.* 1) shows the reinforced concrete framed structure of the turbine house of Skelton Grange B Power Station which is being constructed for the Central Electricity Generating Board at Leeds. (A description of the design and construction of the concrete structure forming the turbine house of the first part of this station was given in the number of this journal for February 1950.) The new structure is 450 ft. long, 120 ft. wide and about 100 ft. high.

The main columns were cast insitu but the remaining members were precast. The

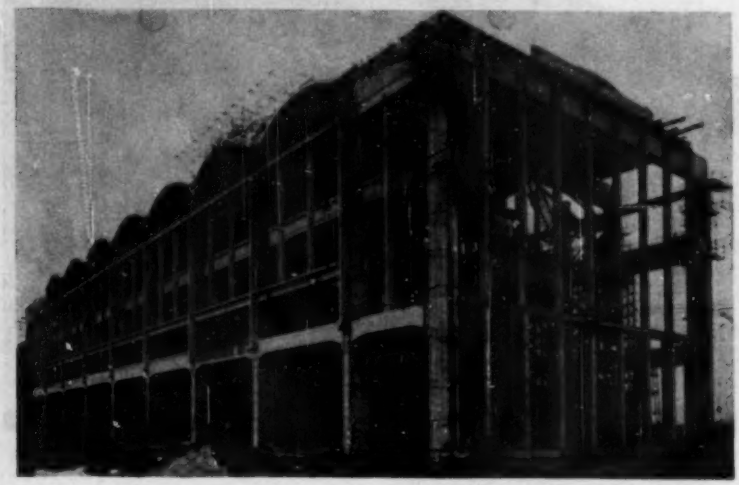


Fig. 1.—Turbine House, Skelton Grange.

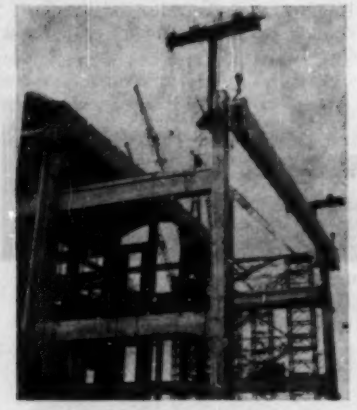


Fig. 2.

main beams of the roof were cast in eight sections which were prestressed together on the ground. Each complete beam weighs 80 tons and was lifted into position from masts erected on top of the columns (*Fig.* 2). All other units were limited in weight to 15 tons and erected by a derrick crane with 150-ft. jib. The shell roof was precast in sections, there being nine sections in each bay. The flat roofs at the ends, which form thrust girders for the roof, were also precast. The rail-beams for the 150-ton overhead travelling crane were each precast in two longitudinal sections for each bay and were prestressed by post-tensioned cables before lifting into position.

The consulting engineers are Sir Alexander Gibb & Partners in association with Messrs. Merz & McLellan. The contractors are Messrs. J. L. Kier & Co., Ltd.

Extension of Llangollen Grammar School.

THE extension (*Fig.* 1) of the Grammar School at Llangollen includes classrooms, laboratories and a gymnasium. Because of the hilly nature of the district and in order to retain the playing fields, it was necessary to provide multiple-storey buildings which comprise a four-storey laboratory block (170 ft. by 26 ft.), a three-storey classroom block (110 ft. by 23 ft. 6 in.), a foyer with a small hall above

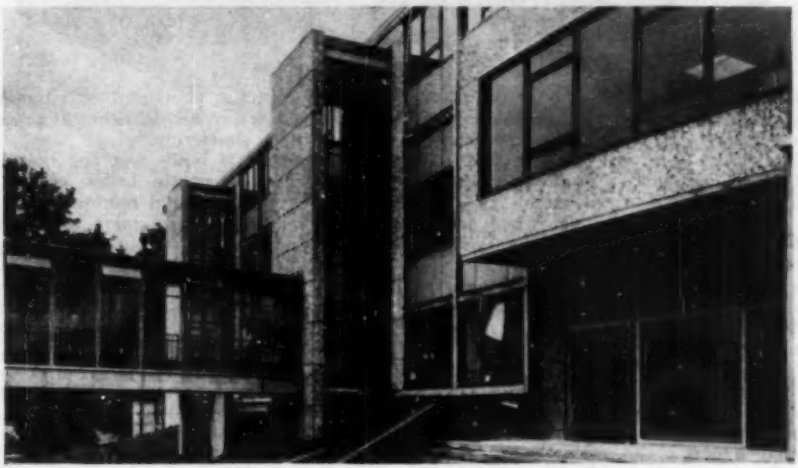


Fig. 1.—New School at Llangollen.

(46 ft. 8 in. by 27 ft. tapering to 15 ft. 8 in.), a block of three storeys containing an assembly hall and the gymnasium (67 ft. by 46 ft. 8 in.) with a stage and changing rooms, and a kitchen block with a boiler-house (50 ft. by 32 ft. 6 in.), a bridge to the old school and a smaller bridge to the playing fields.

The structures are cast-insitu reinforced concrete frames. The laboratory block is supported on 9-in. square columns, with projecting fins, at 10-ft. centres. The columns support, at each floor, beams 15½-in. deep spanning 24 ft. across the width of the block. The beams support a 4-in. floor slab. A smooth finish was produced on the fin on the columns by using a hardboard liner in the shuttering; no rubbing down was necessary. The horizontal beams are visible at each floor level. A cantilevered bracket is provided at the top of each column to support the cradles for window cleaning and maintenance. The transverse roof beams support longitudinal timber beams supporting a lightweight roofing material. The roof beams are larger adjacent to each of the two stairs in order to support some water tanks, and the structure below is designed to resist the possible racking effect which may arise if the tanks are filled before the completion of the brick infilling.

The assembly hall and gymnasium block is at right-angles to and at one end of the laboratory block. The floor of the gymnasium (*Fig.* 2) has a span of 66 ft. 8 in. by 46 ft. 8 in. and is supported on a perimeter beam 27 in. deep. The floor (*Fig.* 3) comprises 17-in. (net) by 6-in. tee-beams at 3-ft. 4-in. centres in both directions. The entire floor was hogged during construction so as to leave an upward camber of ¾ in. on completion. The columns of the assembly hall support the perimeter beam and are at 13-ft. 4-in. centres. The size of the columns on one side is 12 in. by 9 in. up to the gymnasium floor and 9 in. square above; on the other side, the basic size is 9 in. by 7½ in. with a 9-in. by 6-in. fin up to the gymnasium floor and

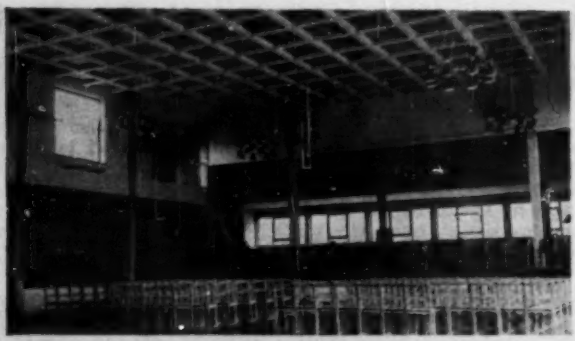


Fig. 2.—Floor of Gymnasium.

9 in. square above. The roof of the gymnasium (*Fig.* 4) comprises a 4-in. slab spanning 13 ft. 4 in. between transverse beams 5 ft. 9 in. deep by 9 in. wide, the beams being partly upstanding and showing as an architectural feature.

The small hall and foyer, which are between the assembly hall and the classroom block, are tapered in plan from 15 ft. 8 in. wide at the rear to 27 ft. wide over the entrance. The beam, 27 ft. long at first-floor level, is curved in plan to a radius of 143 ft. It is supported on the one side by the perimeter beam of the gymnasium floor and on the other by a cantilever which is the extension of the perimeter beam of the small hall. The floor of the small hall is a 4-in. slab.

The construction of the classroom block is generally similar to that of the laboratory block, but as the ground at the front of the block falls away steeply to the road, this part is supported on circular columns, for which asbestos-cement pipes were used as shuttering.

The kitchen is built over the boiler-house, which is partly below ground. The lower part has solid reinforced concrete walls acting as retaining walls, on which stand 9-in. square columns carrying 17½-in. by 9-in. floor beams 32 ft. long but supported intermediately on a load-bearing brick wall. The columns continue upwards to support the roof beams of the kitchen; the beams are 16½ in. by 9 in. and span 31 ft. and support a 4-in. reinforced concrete slab in which there are openings for roof-lights.

The bridge from the new classroom block to the old school is carried on four 10-in. square columns and is separated from both structures. It comprises two 11-in. by 12-in. beams extending over a span of 24 ft. and cantilevering 9 ft. at

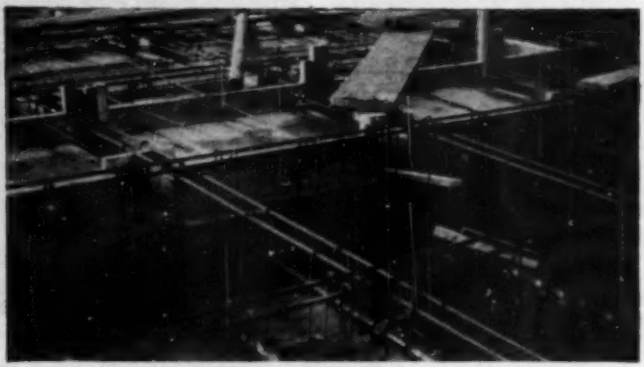


Fig. 3.—Construction of Long-span Floor, Llangollen.

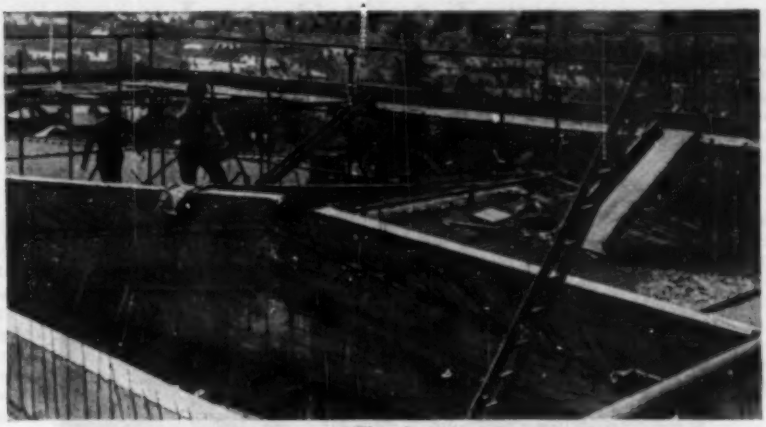


Fig. 4.

one end and 5 ft. at the other. The beams support a 4-in. slab. The bridge to the playing fields comprises two 7-in. by 7-in. beams spanning 22 ft. and supporting a 5-in. slab.

A good bearing stratum occurs at about 8 ft. to 10 ft. below the surface of the ground. Plain concrete bases are provided and support reinforced concrete ground beams. A fault running diagonally across the site makes it necessary to provide deeper foundations for a few of the bases.

The laboratory and classroom blocks are clad with timber panels between the windows and with exposed-aggregate concrete slabs, carried on light steel-work, at the gable-ends and at the stairs (*Fig.* 1). The gymnasium, assembly hall and kitchen are clad with brickwork.

The work was designed by Mr. R. A. MacFarlane, A.R.I.B.A., Architect to Denbighshire County Council. Johnson's Reinforced Concrete Engineering Co., Ltd., were responsible for the design of the reinforced concrete frame. Messrs. William Thornton & Sons, Ltd., carried out the reinforced concrete work. The general contractors were Messrs. W. F. Humphreys (Acrefair), Ltd.

Lectures on Building.

THE following lectures have been arranged by the Ministry of Works. Admission is free.

Concrete Placing and Formwork. By A. B. Harman. Cambridgeshire Technical College, Collier Road, Cambridge, January 16, 7.30 p.m.

Practical Formwork Design and Construction for Concrete. By J. G. Richardson. Gas Showrooms, Sandgate Road, Folkestone, January 16, 7.15 p.m.

Concrete Handling on Building Sites. By A. W. Rickard. Percival Whitley College, Hopwood Lane, Halifax, January 18, 7.15 p.m.

Essentials of Good Concreting. By E. E. H. Bate. West Wiltshire and Trowbridge College of Further Education, College Road, Trowbridge, January 18, 7.15 p.m.

Prevention of Accidents in the Building Industry. By J. A. Hayward. Old Technical College, Chesterfield Road South, Mansfield, January 19, 7.15 p.m.

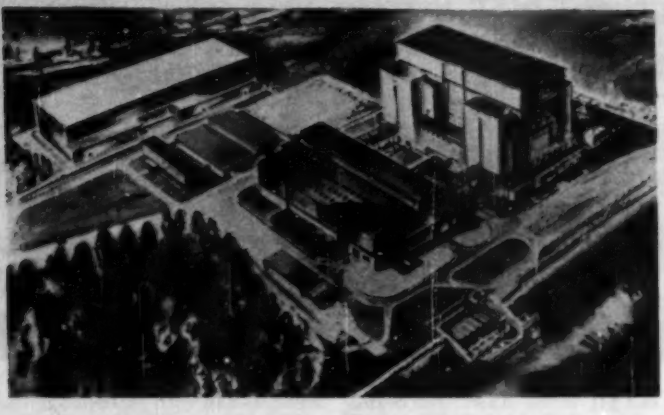
Practical Aspects of Site Investigation. By J. S. Button. South Dorset Technical College, Newstead Road, Weymouth, January 19, 7.15 p.m.

The Settlement of Buildings. By S. R. Rosenak. 34 Queen's Gate, London, S.W.7, January 23, 7 p.m.; and City College and Art School, Ipswich Road, Norwich, January 24, 7 p.m.

New Techniques in Building. By D. Bishop. Y.M.C.A., Blackett Street, Newcastle-upon-Tyne, January 24, 7.15 p.m.

The R.I.B.A. Form of Contract. By D. Gardam. Mackworth Hotel, Swansea, January 24, 7 p.m.

Sizewell Nuclear Power Station.



THE contract for the nuclear power station to be built at Sizewell, on the coast of Suffolk, for the Central Electricity Generating Board has been awarded to the English Electric, Babcock & Wilcox, Taylor Woodrow Atomic Power Group, the value of the contract being about £55,000,000. The capacity of the station, an artist's impression of which is reproduced, will be 580,000 kw., which will be the highest output of the seven commercial nuclear power stations in hand in the United Kingdom. Construction is to begin in April next and the station is planned to be in operation in 1966. Like the other stations, there will be two gas-cooled graphite-moderated reactors of an improved Calder-Hall type. New features of the design, resulting in compactness of the station, include one building to contain both reactors, small pressure-vessels with thick walls, few boilers (heat exchangers) each of high capacity, and the provision of only two turbines of large output thereby reducing the size of the turbine hall.

Features of the civil engineering work include the construction of a cooling-water intake 1400 ft. from the shore through which sea-water will be drawn at the rate of more than 27,000,000 gallons an hour, and two underwater tunnels of 10 ft. diameter. Two outfall tunnels from a deep shaft will return the cooling-water to the sea at the southern end of the station. Driving of the tunnels will be carried out continuously using compressed air. The 400-ton goliath crane, which has now almost completed its work at Hinkley Point (see this journal for December 1960), will be used at Sizewell.

The height and length of the reactor building will be 193 ft. and about 400 ft. respectively. The average thickness of the main concrete shield will be 5 ft. 6 in. and of the supplementary shield will be 5 ft.

The distance across the flats of the main shield will be 72 ft. 3 in., and the height of this shield will be 86 ft. 2 in. The thickness of the cap over the reactors will be 11 ft. 9 in. The foundation of the reactor building will be a reinforced concrete raft 225 ft. by 110 ft. and 8 ft. thick. The turbine hall will be about 385 ft. long, 155 ft. wide, and 94 ft. high. The pump-house will be 125 ft. wide and 133 ft. long. The consulting architect is Mr. Frederick Gibberd, C.B.E., F.R.I.B.A., and Messrs. C. S. Allott & Son are the consulting engineers for the cooling-water pump-house and off-shore works.

Large Cooling Towers.

In the following are given descriptions of some large hyperbolic cooling towers constructed recently, or in course of construction, for the Central Electricity Generating Board.

Rugeley Power Station.

Five reinforced concrete cooling towers (*Fig.* 1) recently erected at the new electricity generating station at Rugeley, Staffordshire, include one which, it is claimed, is the largest of its kind, being 325 ft. in diameter at the base and 350 ft. high, and is the first in this country to be erected in connection with the Heller system, an Hungarian method of dry-cooling. Adoption of this system enables power stations to be erected at sites independent of water supplies since there are no losses due to evaporation from the tower, and no replenishment of cooling water is required. The tower is associated with the principal component of the dry-cooling plant, namely the special aluminium cooler-elements or heat-exchangers, which are situated around the periphery of the tower.

The wall of the tower, which is of normal reinforced concrete construction, is 5 in. thick with a walkway cornice acting as a stiffener around the top. The air intake opening is 53 ft. above the ground; this dimension is to the base of a canopy, which projects from the base of the wall. The inclined columns supporting the structure are about 70 ft. high from the separate foundation bases to the bottom of the wall. The columns are 3 ft. by 1 ft. in cross-section and intersect twice in their length as seen in *Fig.* 1. At each intersection, nodes are provided which enabled the column to be rotated slightly while maintaining the axis of the column in a straight line. This rotation is necessary in order to minimise the size of the lower nodes. The shape of the columns reduces their resistance to the inflow of air. To obtain an economical arrangement of the cooler unit, it was necessary for the columns to be inclined at an angle slightly different from the line of thrust of the base of the wall. At the junction of the canopy, therefore, a ring-beam 3 ft. wide is provided and is suitably reinforced to resist the out-of-balance forces due to the change in direction of the line of thrust.

The cooler elements are in the form of columns each 48 ft. high and 9 ft. wide; each column is inclined, in a horizontal plane, at an angle of 60 deg. to the adjacent columns so that in plan the columns for the cooler elements are arranged in V-formation around the base of the tower. It is essential that the bottom fixings of these columns, which are on reinforced concrete plinths 5 ft. high,

Fig. 1.

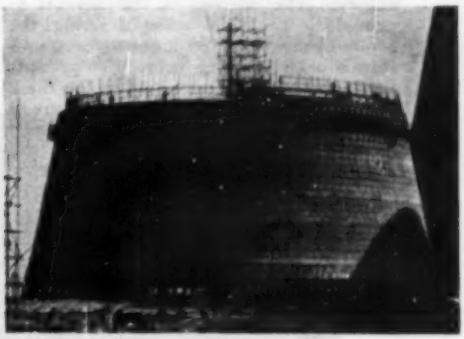


Fig. 2.

Cooling Tower at Rugeley.

Fig. 3.—Base of Cooling Tower at High Marnham.

and the top fixings, which are to the outside of the canopy beam, should be positioned accurately.

An access opening 15 ft. square is provided to the interior of the tower, in which a drain-down tank and valve house are provided. There is no pond as is required in a wet-cooling tower. The level of the ground water is only 3 ft. below the surface and the storage tank and valve house are subjected to an upward pressure due to 14 ft. of water. In the case of the tank it was necessary to provide a thick concrete base to prevent flotation when empty. The purpose of the tank is to provide a reservoir when draining the cooler-elements if the ambient temperature is below freezing point. To prevent thermal stresses being set up in the thick base due to the differential temperature of the water entering the tank, the steel lining of the tank is insulated from the concrete base by being bedded on sand overlying a 6-in. layer of insulating concrete; it was also separated from the concrete walls by a joint-filler 1 in. thick.

Bird-cage scaffolding was used for the construction of the inclined columns, the base of the wall and the canopy. The wall of the cooling tower was constructed by the use of a climbing scaffold attached to the wall in the usual manner (*Fig.* 2).

Messrs. L. G. Mouchel & Partners were the consulting engineers to The English Electric Co., Ltd., who were responsible for the cooling system. Messrs. J. L. Kier & Co. (London), Ltd., were the contractors.

High Marnham Power Station.

The five cooling towers at the power station at High Marnham, Nottinghamshire, will be among the largest in Europe; the height of each tower is 340 ft. Four of the towers, which can cool by 17 deg. F. 5,400,000 gallons of water hourly, are in operation. The external inclined circular columns, and the central-feed tower with orifices for the radial distribution pipes, are shown in *Fig.* 3. The pipes discharge through sprinklers and the resulting fine spray of water falls through wooden louvres to the pond. The louvres are supported on a precast concrete structure about half of which is shown completed in the photograph.

The contractors for the towers at High Marnham are The Mitchell Construction Co., Ltd. The towers were designed by Messrs. L. G. Mouchel & Partners.

New Jetties at Milford Haven.

Two large jetties capable of accommodating oil tankers of up to 100,000 tons dead weight have recently been constructed at Milford Haven, Pembrokeshire. In both jetties extensive use is made of precast concrete.

A JETTY WITH PRESTRESSED PRECAST PILES.

The jetty for the Esso Petroleum Co., Ltd. (*Fig.* 1), comprises a pier 3500 ft. long and a berthing-head 2600 ft. long. Three berths are provided, one for coastal vessels and one, 350 ft. long and 50 ft. wide, at each end of the berthing-head for the largest tankers. Piled dolphins are provided capable of withstanding forces of up to 100 tons. An administration building, a car park and a floating landing stage are also provided at the berthing-head. There are four fenders at each main berth, Each fender is a welded frame of steel piles and walings comprised of 36-in. by 12-in. steel beams and is faced with greenheart. Steel-spring and rubber buffers assist in absorbing impact.

The pier is supported on pairs of prestressed precast piles at 35-ft. centres with raking piles at intervals to provide added stability. Some of the piles were driven in 70 ft. of water, through 50 ft. of silt, sand and gravel to rock. Each pair of piles supports two transverse precast beams (*Fig.* 4) which carry pipe tracks at two levels and a 16-ft. road. The road is formed of precast slabs 35 ft. long and 8 ft. wide. The precast units, which weigh up to 18 tons, were placed in position by an 18-ton self-propelled floating crane or by a 20-ton steam derrick with a 120-ft. jib, mounted on a pontoon. The structure was made monolithic by concrete cast insitu between the precast units. Precast slabs were used as permanent shuttering for the berthing-head and dolphins and were strengthened (*Fig.* 2) by small steel trusses which later became part of the reinforcement of the superstructure. Concrete which was cast insitu was mixed in barges and placed by floating cranes.

Making the Piles.

More than nine hundred hollow cylindrical prestressed piles of 22-in. and 27½-in. diameter were driven, and some of them, which are over 140 ft. long, are believed to be the longest of this type driven in Great Britain.

The piles and all the other precast units were made at a yard about half a mile inland. The piles were made by the long-line process and were cast in five moulds side by side on a stressing bed which was 500 ft. long (*Fig.* 5). Forty 0·276-in. high-tensile wires in each pile were tensioned in groups of 20 by means of a 120-ton hydraulic jack (*Fig.* 6) with an extension of over 3 ft. The cores for the hollow piles were formed by a patented method. Wires of 0·20-in. diameter, extending the length of the bed and arranged uniformly around the perimeters of circular concrete spacers, were tensioned and waterproof paper was wound around the wires to form the surface of the core.

The concrete for the piles was mixed in a 14/10 mixer and had a cube strength of at least 4500 lb. per square inch at three days and 7500 lb. per square inch at

Fig. 1.—Jetty for the Esso Petroleum Co., Ltd.

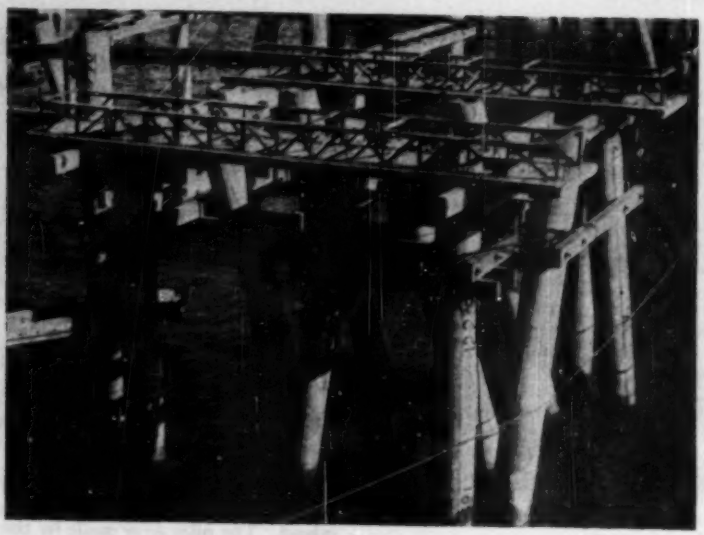


Fig. 2.

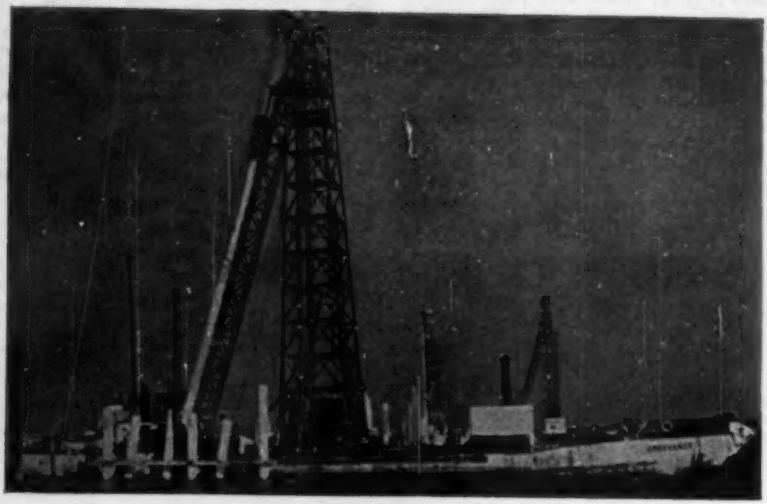


Fig. 3.

Fig. 4.

twenty-eight days. Rapid hardening cement was used with granite aggregate of ¾-in. maximum size, the mixture being in the proportions 1 : 1·15 : 2·35 with a water-cement ratio of 0·45. The concrete was placed from 1-cu. yd. skips suspended from a travelling gantry spanning the bed (*Fig.* 5). A small locomotive running on a narrow-gauge rail-track transported the skips from the mixer to the gantry.

Compaction of the concrete was by external vibrators which were clamped transversely to a mould and moved along the mould as casting proceeded. About three days after the piles had been cast the moulds were removed, the wires of the hollow core withdrawn and the prestressing wires released. The piles were then separated and moved to storage to mature. About half a mile of piling was produced by this method each week.

Driving the Piles.

From the curing area the piles were transported by a special 12-ton lorry and 15-ton trailer to a temporary jetty from

Fig. 5.

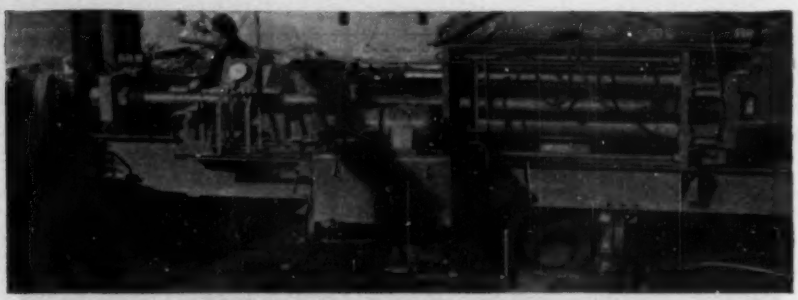


Fig. 6.—Prestressing Jack.

which the piles and other precast units were loaded by a 20-ton electric derrick on to pontoons and towed to the site of the permanent pier. The piles were driven by 8-ton and 10-ton semi-automatic steam hammers operating in two special 95-ft. raking frames (*Fig.* 3). The frames were mounted on vessels and could give the piles a rake backwards of 1 : 3. The suspended leaders were capable of providing a similar rake sideways and could be rotated to face outwards or to either side.

The jetty was designed and constructed by Messrs. John Mowlem Co., Ltd. The 95-ft. piling-frame was supplied by the British Steel Piling Co., Ltd.

A JETTY WITH PRESTRESSED CONCRETE DECK.

The jetty for the B.P. Trading Co., Ltd., at Angle Bay comprises a pier 1350 ft. long and a berthing-head which, including the outer dolphins, is 2500 ft. long. There are eleven plain concrete dolphins at intervals along the berthing-head, five at the main jetty which carries the pipes and is 1200 ft. long, and three similar dolphins at each end of this part and connected to it by walkways. The fendering system comprises four weights of 100 tons suspended on swinging links and projecting beyond the face of the berthing-head. Two pairs of dolphins can resist the forces due to the berthing of two tankers of up to 100,000 tons dead weight. Between each pair of dolphins there is a structure for handling the discharge hoses.

The jetty, on which there is a 16-ft. road and a pipe-track, which is 32 ft. wide on the pier and 26 ft. wide on the berthing-head, is constructed of prestressed precast slabs and transverse beams supported by three rows of steel hexagonal box-piles. The precast units, which weigh up to 15 tons each, were produced at a yard on-shore where they were handled by two electric gantry hoists. The units were brought to the pier on bogies drawn by tractors, and were placed in position by another gantry hoist.

High-tensile steel bars 1¼ in. in diameter were used to prestress insitu the road slabs transversely and to connect the slabs and beams longitudinally. Each bar exerted an initial prestressing force of about 42 tons. The concrete for all the precast members was 1 : 1½ : 3 and had a strength of at least 5500 lb. per square inch at twenty-eight days. Concrete cubes and aggregate were tested at a laboratory in the yard.

Constructing the Dolphins.

The dolphins, the foundations of which are as deep as 65 ft., were constructed in cofferdams of steel sheet-piles. The interiors of the cofferdams were excavated by mechanical grabs and divers. About 8000 cu. yd. of plain concrete was placed in each dolphin in layers 6 ft. to 8 ft. thick, the laitance being removed from the surface of each layer by divers before new concrete was placed. The nominal mixture of the concrete was 1 : 2½ : 5, but an extra 25 per cent. of cement was added to compensate for underwater placing, the actual mixture being about 1 : 2 : 4. This concrete had a strength of about 3000 lb. per square inch at twenty-eight days.

Concrete for the dolphins was mixed in a batching and mixing plant mounted on a pontoon (*Fig.* 7). The pontoon, which

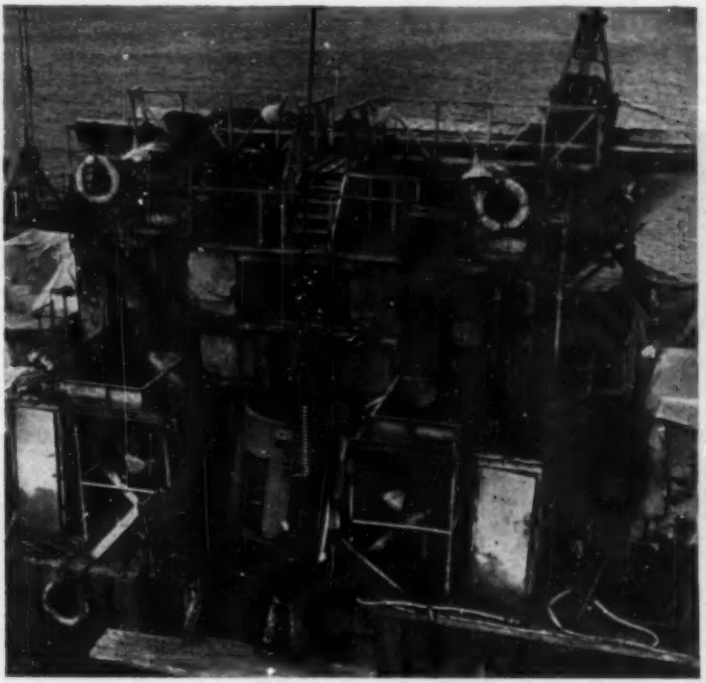


Fig. 7.—Concrete Plant on Pontoon.

was moored to the cofferdams, was 104 ft. long, had a beam of 24 ft. and a draught of 4 ft., and carried two cranes, two weigh-batchers of 30-cu. yd. capacity and two concrete mixers of 28-cu. ft. capacity. Ancillary equipment on the pontoon included a 75-ton fresh-water tank, two generating sets, pumps, hand-winches for positioning the pontoon, and two mechanical grabs for loading aggregate into the bins of the batching plant. Up to 100 tons of cement in bags was stored on the deck of the pontoon and protected by tarpaulins. The aggregate bins discharged through lever-controlled radial gates to a 60-cu. ft. hopper in which the aggregate was weighed. The number of bags of cement required were added to each batch by hand. A radial gate at the bottom of the hopper was opened and closed automatically by a skip which travelled in guides and carried material from the batchers to the mixers. On leaving the mixers concrete for the dolphins passed through hoppers and retractable chutes to 4-cu. yd. bottom-dump buckets for placing under water. The buckets were handled by derricks mounted on the piles of the hose-handling structure.

The consulting engineers are Messrs. Rendel, Palmer and Tritton. The contractors were Messrs. Christiani and Nielsen, Ltd., and the concreting plant was supplied by Blaw Knox, Ltd.

Ministry of Transport.

THE Highways Department of the Ministry of Transport have moved to new offices at St. Christopher House, Southwark Street, London, S.E.1, where copies of draft and made Orders and Schemes deposited for public inspection at the Department's former offices are available.

An Office Building of Thirty-four Storeys in London.

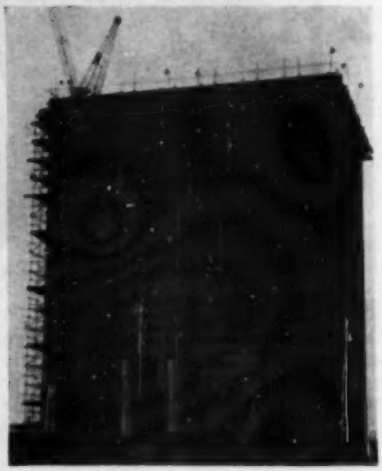
Fig. 1.

A DEVELOPMENT on Millbank, Westminster (*Fig.* 1), comprises a tower-block of offices of thirty-four storeys and 386 ft. high, an eight-storey Y-shaped block 90 ft. high, and an eleven-storey residential block 120 ft. high. A cinema or conference hall is provided on the ground floor. There will be car parks for about 250 cars on three floors, access to which is to be by means of a helical ramp cantilevered from a water tower. The storey-height in the offices is 10 ft. 9 in.

Structural work throughout has been kept as light in weight as possible and is of reinforced concrete. Bored-pile foundations are provided. The floors in the tower-block are of prestressed precast units. The cladding of the office blocks is of stainless steel with glass panels. The facings of the columns will be of marble or bush-hammered or fair-faced concrete, depending on the position. The exposed concrete framing, panels, fascias, and the like will generally be faced with white vitreous mosaic. The wall panels of the residential block will be of exposed-aggregate slabs using washed mill flints and Cornish granite.

Construction commenced in June 1959 and is expected to be completed by the end of 1962. The development has been commissioned by Messrs. Vickers, Ltd., and financed by The Legal & General Assurance Society, Ltd. The site is owned by the Crown. The architects are Messrs. Ronald Ward & Partners. The consulting engineers are Messrs. R. Travers Morgan & Partners. The contractors are Messrs. Mowlem, Ltd.

Silo at Gainsborough.



THE illustration shows a reinforced concrete silo completed recently at the site of the new factory for Messrs. Spillers, Ltd., at Gainsborough. The walls which are 120 ft. high were constructed in ten days using continuously-moving shuttering operated by hydraulic jacks. Concrete was handled by a 2-ton tower-crane 140 ft. high.

The consulting engineers are Messrs. Oscar Faber & Partners. The main contractors are Messrs. Bierrum & Partners, Ltd.

A Subway in an Existing Building.

For the new die-casting shop of Copper Alloys, Ltd., at West Bromwich, a service subway (*Fig.* 1) 255 ft. long was constructed inside an existing building. The subway, which is to serve up to twenty-five die-casting machines, the largest of which has a die-lock of 1500 tons, is 6 ft. wide and 7 ft. 3 in. high. Provision is made for water supply and return mains, an oil main, gas pipes, compressed-air pipe, hydraulic exhaust, hydraulic pressure mains and electric cables. The pipes are supported on the walls and inserts were cast in the concrete for this purpose. Side ducts are provided to enable the services to branch off to the machines which are located, on plan, on each side of the tunnel.

The excavation for the subway is in filled ground. The base is founded on soft clay, load-bearing tests on which indicated a safe working pressure of ½ ton per square foot. As the roof of the subway and the floor of the workshop adjacent to the subway have to be capable of supporting 5-ton dies, cantilevered slabs project 5 ft. 3 in. from both sides of the roof of the subway; the slabs have a maximum thickness of 15 in. and are reinforced with ¾-in. diameter bars at 5-in. centres. The foundation slab also projects on each side to enable the pressure on the ground to be kept within the permissible amount. The entire subway is assumed to span horizontally and to spread the force of several dies including the impact when they are being placed on the slab. The walls and base slab are 9 in. thick. The reinforcement bars in the wall vary from ¾-in. diameter at 5-in. centres to ¾-in. diameter at 5-in. centres. Access is at each end of the subway. Expansion joints are provided. Ready-mixed concrete was used throughout and had a guaranteed

Fig. 1.—Subway at Works at West Bromwich.

strength of 3000 lb. per square inch at twenty-eight days. Impact hammer tests were made on site. The quality of the concrete was most consistent and the strengths obtained were generally about 3700 lb. per square inch at seven days.

The consulting engineers are Messrs. Walter C. Andrews & Partners who worked in association with the contractors, Messrs. E. E. Jeavons & Co., Ltd.

Completion of Colne Viaduct, Uxbridge.

Reinforcement in Main Girders, Colne Viaduct.

THE illustration shows the reinforcement in one of the main girders of the widened part of the viaduct which carries Western Avenue over the River Colne to the west of Uxbridge. There are 340 tons of 1¼-in. and 1½-in. diameter mild-steel bars in the structure; the lengths of bars vary from 40 ft. up to 90 ft. The structure, which comprises reinforced concrete beams and slabs, is 1500 ft. long and has one span of 125 ft., two spans of 95 ft., and several spans of 65 ft. The beam shown in the illustration is 13 ft. 10 in. deep at the support and tapers to 3 ft. deep in the span.

The cost of the work, which is still in course of construction, will be about £128,000. The structure was designed by Mr. H. S. Andrew, M.I.C.E., Engineer to the County Council of Middlesex. The contractors are Messrs. Howard Farrow, Ltd.

Multiple-storey Car Parks.

In the number of this journal for March 1960 a description was given of a multiple-storey car park which at the time was in course of construction in Bristol. This reinforced concrete building, which is now completed and an illustration of which is given in *Fig.* 1, comprises a continuous ramp and was the first of its kind in this country. It can accommodate 550 cars. The ramp, which is 56 ft. wide, has a gradient varying from 1 in 32 to 1 in 46 and is about ¼ mile long. The time of construction was eleven months. The contractors were Messrs. William Cowlin & Sons, Ltd.

A similar structure, but of about twice the size of that at Bristol, is being constructed at Leicester (*Fig.* 2), and another is about to be commenced at Bath (*Fig.* 3). The columns and beams are of cast-insitu reinforced concrete. The floors are of composite construction consisting of precast ribs and cast-insitu topping. The balustrades will be precast and will have

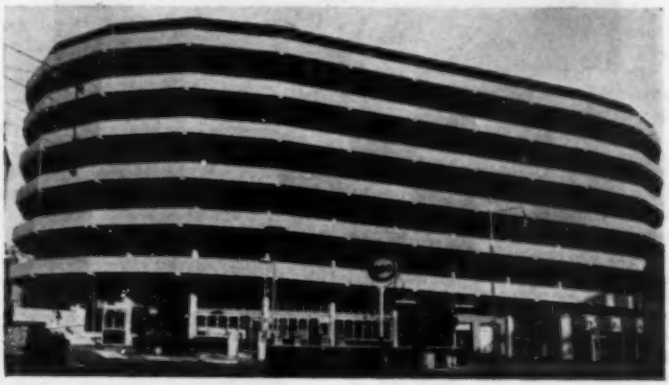


Fig. 1.—Car Park at Bristol.

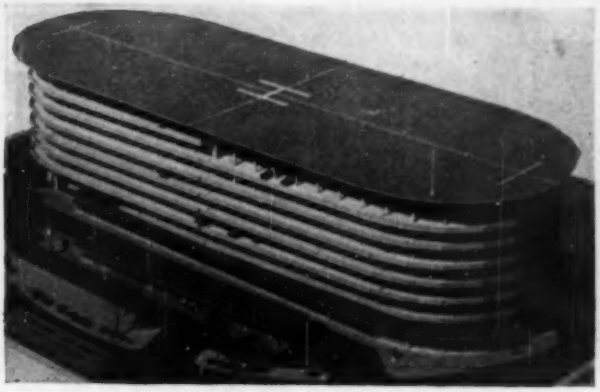


Fig. 2.—Model of Car Park at Leicester.

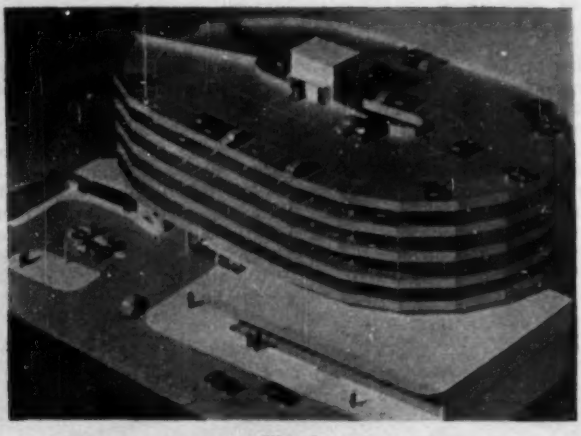


Fig. 3.

an exposed-aggregate finish on the outer face. Both buildings have a continuous ramp of uniform slope of about 1 in 30. Parking is on both sides of the ramp at right-angles to the roadway, which will be 24 ft. wide. The capacity of the building at Leicester will be 1140 cars, and it is being constructed with a double ramp and therefore will have two entrances. In the case of the building at Bath, there will be only one entrance and one ramp for a capacity of about 500 cars. In both structures the ground floor at street level will contain showrooms, workshops, and the like, and a petrol station.

The car parks at Bristol, Leicester and Bath are for Multidek Car Park Developments, Ltd., the consulting engineers being Mr. E. N. Underwood and Messrs. G. C. Mander & Partners.

Fig. 4.—Car Park for East London.

Car-park Buildings in London.

The illustration *Fig.* 4 is from an artist's impression of the car-park building it is proposed to erect at Houndsditch, London, and for which planning approval of the London County Council has been received. This building, which will be a reinforced concrete structure with prestressed precast flooring, will contain a central lift-tower giving access to the floors, and is to be constructed for Parcar, Ltd., the contractors being Unit Construction Co., Ltd., and Mitchell Engineering Co., Ltd.

A mechanical car park is also to be constructed by Parcar Ltd., at Shoe Lane, London. The building will be of reinforced concrete and will contain twelve storeys providing accommodation for 280 cars. Work on the site is about to start.

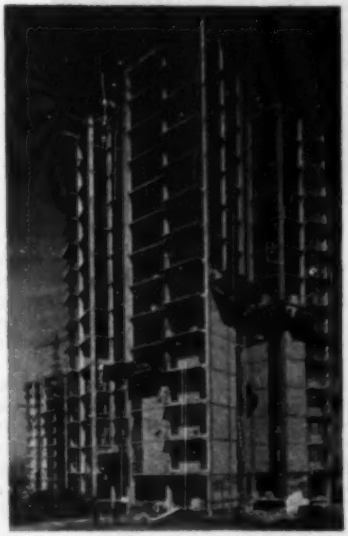
Fig. 5.—Model of Car Park at Bedford.

At Woolwich a nine-storey reinforced concrete car-park structure comprising precast columns and beams, bolted together and grouted under pressure, is in course of erection. The wall and floor panels are also precast. All the precasting is being done on the site. The building was designed for the Woolwich Borough Council by Messrs. T. and P. H. Braddock, F/A.R.I.B.A. The design of the frame and the construction is being carried out for Auto-Stackers, Ltd., by Truscon, Ltd. The auto-stacker is a fully-automatic mechanical parking device, and the car-park building at Woolwich is the first time it has been used in this country.

A Car Park at Bedford.

A multiple-storey car park (*Fig.* 5) for 569 cars is in course of construction for the Bedford Borough Council. The structure comprises five flat-slab floors. Glass-fibre shuttering is being used. The external ramps are provided with heating devices. The scheme was designed by Mr. F. W. Dawkes, the Borough Engineer and Surveyor. The contractors are Messrs. Holst & Co., Ltd., who also prepared the structural designs.

Rapid Construction of Flats at Woolwich.



THE illustration shows one of the fourteen-storey tower blocks of flats being erected for the Woolwich Borough Council. The blocks are 138 ft. high and are of reinforced concrete construction on pile foundations. The wall panels are of flint-lime bricks. The structures are of "butterfly-plan" whereby each of the 279 flats has the greatest amount of natural ventilation and lighting. The total cost is about £620,000. The work was commenced in July 1959 and is expected to be completed early this year.

Construction is proceeding at an average rate of five floors in four weeks and, in spite of bad weather, has never been less than one floor per week. For the erection of the first block a climbing crane was used, but on subsequent blocks the rate of working was increased by the installation of a tower crane outside the structure.

The architects and engineers are Messrs. Norman & Dawbarn. The contractors are Wates, Ltd.

A Tall Office Building at Croydon.

Fig. 1.—Lansdowne House, Croydon.

THE superstructure of the building (*Fig.* 1) to be known as Lansdowne House now in course of construction at Croydon, Surrey, comprises thirteen storeys and is of cast-insitu reinforced concrete acting in conjunction with prestressed precast floor units. All floors and roofs have flush soffits, beams projecting below the soffits being provided only within the thickness of brick walls. The floors are designed for an imposed load of 100 lb. per square foot. The basic spacings of the columns are 25 ft. and 19 ft. transversely and 21 ft. longitudinally. The structure is founded on compact flinty gravel overlying stiff clay and has ordinary reinforced concrete block foundations except for the service and basement area which is on a reinforced concrete raft. Excavation commenced in November 1959.

The architects for the building, which will be occupied by the Royal Automobile Club, are Messrs. R. Seifert & Partners, and the consulting engineers are Messrs. John Bunce & Associates. The main contractors are Messrs. George Wimpey & Co., Ltd.; the precast floor units were supplied by Pierhead, Ltd.

Prestressed Precast Construction of a Silo at Belfast.

THE construction of a silo (*Fig.* 1) having a capacity of about 5000 tons was completed at the beginning of 1960 in connection with a new feeding-stuff mill for Associated Feed Manufacturing, Ltd., Belfast. It is believed that this structure is the first instance in which precasting has been used in the United Kingdom in connection with the construction of silos. An advantage of the process is that care can be taken when precasting to ensure that the surface of the panels is smooth, as this is of great importance in aiding the free flow of the fine pulverised materials which are used for animal feeding stuffs.

The silo is 55 ft. wide and 111 ft. long. The bins are supported on beams prestressed with post-tensioned cables. The reinforced concrete columns supporting the bins are 26 ft. high. There are one hundred bins, about half of which are 9 ft. 3 in. square; the remainder are 9 ft. 3 in. by 4 ft. 7½ in. as shown in the plan in *Fig.* 2. The walls of the bins are built up of precast concrete panels 6 in. thick and each weighing about 4 tons; the separate panels are shown in *Fig.* 2. After the joints between the panels had been filled with mortar, cables consisting of 0·276-in. diameter wires were threaded through ducts formed in the panels and stressed. The panels were prestressed only in the horizontal plane.

The bins are 50 ft. deep (*Fig.* 3), and above them are two floors for housing conveyors and other machinery. The floor immediately above the bins is of cast-insitu concrete with chequer-plate flooring. The slab of the upper floor was also cast insitu. The roof structure comprises frames each of which is formed by two precast columns 21 ft. high and a beam 55 ft. long which was precast in three sections. These units are stressed together

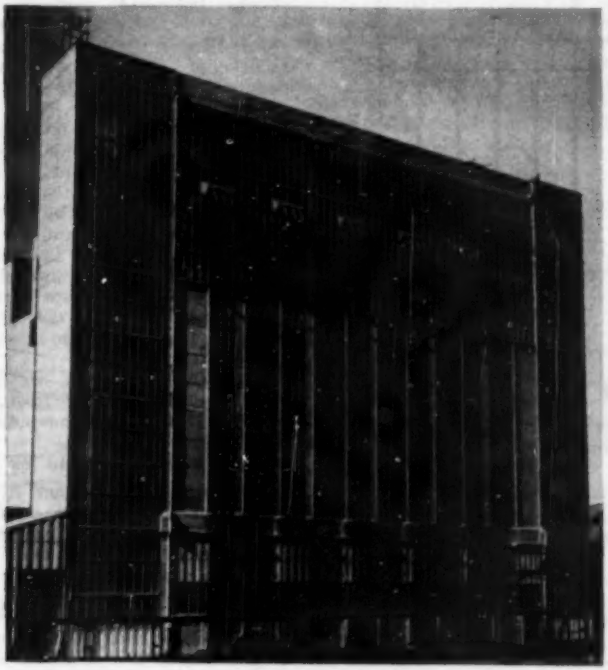


Fig. 1.—A Silo at Belfast.

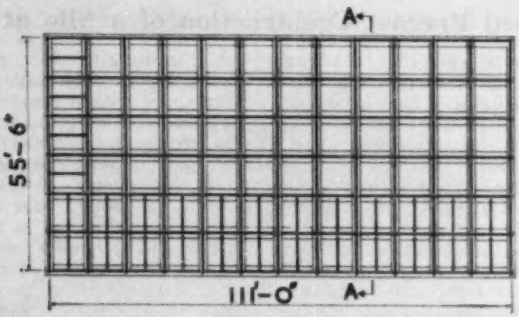


Fig. 2.

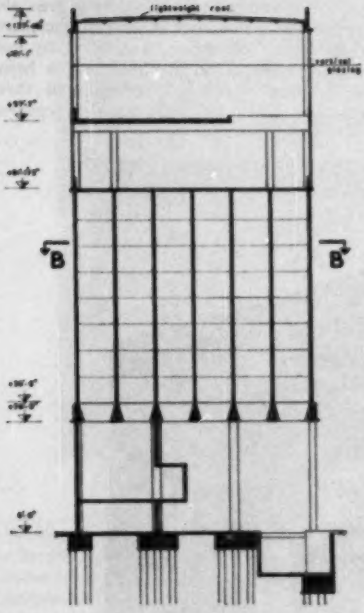


Fig. 3.

with cables to form a portal frame. The top of the roof is 127 ft. above ground.

The silo was designed and constructed by Messrs. Christiani & Nielsen Ltd., who are constructing a similar silo at Bromborough, Cheshire. A silo having panels with pretensioned cables is being built at Birkenhead.

Revised British Standard for Testing Aggregates.

BRITISH Standard No. 812, "Methods for Sampling and Testing of Mineral Aggregates, Sands and Fillers", which was last revised in 1951, has now been further revised and covers and co-ordinates more closely improved methods of tests. Several of the tests in the previous edition are omitted or altered; for example, the attrition test is omitted. Some of the new tests are based on the results of experiments made by the Road Research Laboratory and other laboratories. The new tests include one for indicating the extent to which different types of stone become polished under traffic, the particle shape of aggregates by the determination of an angularity number, and a new method of determining the resistance to crushing. Other important changes include a revised aggregate abrasion test, and the omission of the coloured plate in relation to the estimation of organic impurities.

The revised standard No. 812 (1960) is obtainable from the British Standards Institution (price 15s. plus postage).

An Information Bureau for Builders.

THE National Federation of Building Trade Employers has established a Technical Enquiry Bureau at 82 New Cavendish St., London, W.1 (Telephone Langham 4041). The object of this information service is to give members advice in technical problems relating primarily to materials, including the diagnosis and cure of defects developing during or after construction.

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Barrel-vault Roof of Ashington Technical College.

THE barrel-vault roof shown in *Fig.* 1 is at the workshop building of the new Technical College at Ashington. This is only a small part of the college which also includes a six-storey block 290 ft. long and 52 ft. wide, a lecture theatre, assembly hall and gymnasium, all of which are steel-frame structures. The reason for adopting a barrel-vault roof for the workshop was to provide a clear floor space so that technical equipment could be moved about without structural obstructions. The clear floor area covered by the barrel-vault roof is 58 ft. wide and 300 ft. long.

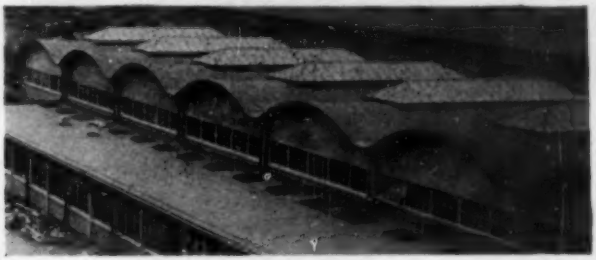


Fig. 1.

The roof consists of ten vaults each 30 ft. wide between the valleys and with a 6-ft. rise. At both ends there is an edge-beam 57 in. deep and 12 in. wide excluding a projecting eaves. Internally the vaults sweep down to a V-point in the valleys the top surface of which is at a radius of 1 ft. 10 in.; the thickness of the slab is greatest in the valleys, where it is 15 in., and tapers in a length of 19½ in. to 6½ in. and then in a length of 3 ft. 9 in. to 2½ in. and this thickness is maintained over the remainder of the vault up to the roof-lights. The roof-lights, which are provided at the crown of each vault, are 8 ft. wide and 37 ft. long. The spandrel walls, which are 6 in. thick, and the slab forming the vault are of reinforced concrete but the two edge-beams and the valleys are prestressed on the Freyssinet system. There are four post-tensioned cables in each edge-beam and six cables in each valley, each cable containing twelve 0·2-in. diameter wires. *Fig.* 2 shows the cables in one of the valleys at the spandrel wall and column head with concreting just commencing. The vaults are supported on 18-in. by 21-in. reinforced concrete columns at both ends of each valley. The columns are on star foundations with cross-ties at alternate columns.

The concrete was of a fairly dry mixture so that the valleys and the part of the slab of the vault beyond the cables could be placed without using top shuttering. The concrete in each valley was deposited in one continuous operation and consolidated by a poker vibrator. The vault slab was not concreted until the next valley had been cast. The work was carried out in two parts, the first being built in 1952; at the end of the fifth vault, the valley was supported on a concrete beam. Building-paper was laid between the V of the valley and the beam, which was supported on an 18-in. brick wall which could be removed when the structure was extended. Four of the six cables in this valley were stressed and a duct was provided for the insertion of the remaining two cables when the extension was constructed.

Extension commenced in 1957. It was necessary first to break away the lime concrete which had been placed around the bars left projecting from the last valley of the first part of the work. The cube-strengths of the concrete in the second part were not less than 5560 lb. per square inch at seven days and were up to a maximum of 9040 lb. per square inch at fourteen days. Stressing could have proceeded within seven to ten days after

Fig. 2.

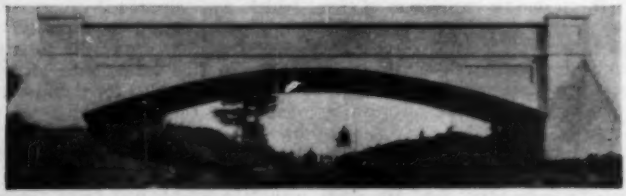
the concrete had been placed but the contractor completed the whole of the concreting before stressing. There has been no differential settlement between the two sections of the work and it is difficult to see where the join occurs.

The college buildings were constructed for Northumberland County Council under the supervision of the County Architect, Mr. C. C. Brown, A.R.I.B.A. Messrs. L. G. Mouchel & Partners were the consulting engineers. The contractors for the first part of the workshop block were Messrs. J. R. Rutherford & Sons, and for the second part, Messrs. Middlemiss Bros., Ltd.

FIFTY YEARS AGO.

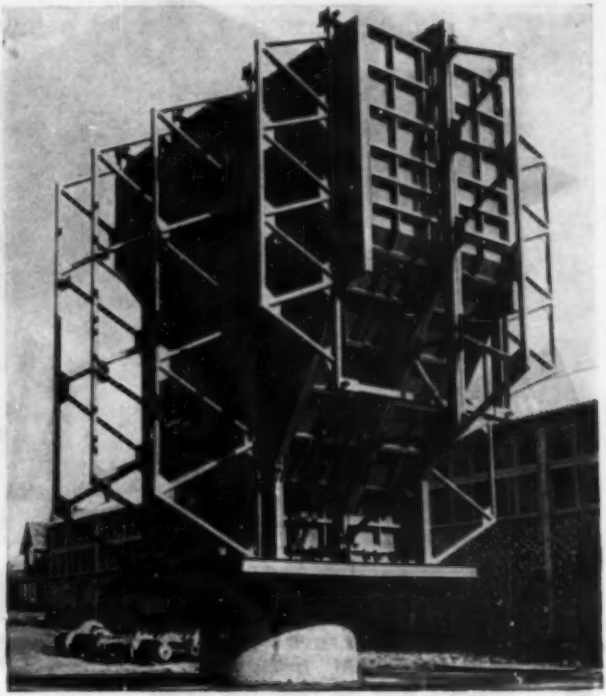
From "CONCRETE AND CONSTRUCTIONAL ENGINEERING", January, 1911.

An Arch Bridge in Dorset.



"Two bridges constructed entirely in reinforced concrete were recently erected in Wimborne, Dorset. The Ringwood Road Bridge (illustrated) is the larger, having a span of 70 ft. The underside of the centre of the arch is 18 ft. 6 in. above the road and the width is 20 ft. All the concrete was mixed by hand in the proportion of 27 cu. ft. of ballast, 13½ cu. ft. of sand, and 5 cwts. of Portland cement. The test load was a 20-ton road roller; six months after the test, the deflection only amounted to a little over $\frac{1}{16}$ inch. The bridges were designed and executed by The Cubitt Concrete Construction Co., Ltd."

Consultants: Sir William Halcrow & Partners
Contractors: The Demolition & Construction Co Ltd



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Widening a Road Bridge at Barking.

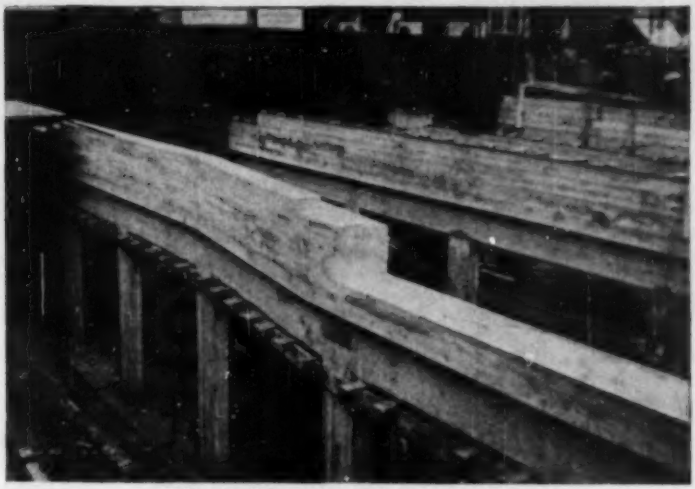

Fig. 1.—East Street Bridge, Barking.

THE constructional work of widening the bridge (*Fig.* 1) which carries East Street and a row of fifteen shops over the railway at Barking, Essex, includes cast-insitu piles, articulated pile-caps, and cast-insitu reinforced concrete frames, which support the deck. The deck units are variously of reinforced concrete and prestressed precast concrete with pretensioned and post-tensioned wires. The frames for the shops will be of reinforced concrete. Work commenced in May 1960, and is expected to be finished in May 1961. The value of the work will be about £140,000.

The consulting engineer is Mr. J. C. Maxwell-Cook. The main contractors are Messrs. Charles R. Price. The piling was carried out by The Cementation Co., Ltd. The prestressed precast and precast reinforced concrete units are being supplied by Messrs. Cawood Wharton & Co., Ltd.

Films on Civil Engineering and Building.

THE Technical Information Service of the Ministry of Works has issued an annual selected list of one hundred and twenty-eight technical films dealing with many aspects of building. The Ministry also acts as distributor for films made by the Building Research Station and these are included in the list. The films are 16 mm.; most of them are sound films and many are in colour. A brief synopsis of each film is given. With few exceptions, the films are lent free of charge to firms, societies and educational establishments connected with building. Copies of the list can be obtained free from Regional Technical Information Officer, Ministry of Works, Room 225, Lambeth Bridge House, London, S.E.1.

A list of films on safety in the civil engineering industry has been issued by the Federation of Civil Engineering Contractors. The films are classified under three main headings, namely, films most suitable for management, films most suitable for supervisors and safety officers, and films most suitable for operatives. The films are 16-mm. sound films and some are in colour. The list gives details of the content of the film, the running time, and from where it can be obtained. Some of the films have a civil-engineering setting and are directly appropriate to the industry; others, although taken in factories, illustrate safety principles which are applicable to civil engineering and building.

Investigations by the Building Research Board.

SOME of the problems concerning concrete construction are the subject of investigations by the Building Research Board and are described in "Building Research 1959" (published recently by H.M.S.O., price 7*s*.). The results of some of this work are as follows.

Shearing Resistance.

The completion of the first stage of the investigation of the shearing resistance of reinforced concrete beams confirms that the basis of design recommended in British Standard Code No. 114 for beams without reinforcement to resist shearing does not provide the degree of security appropriate to the load-factor method of design. Another basis of design has been derived which requires the provision of reinforcement to resist shearing for appreciably smaller shearing stresses and ensures that in the event of overloading failure by bending occurs before failure by shearing.

Placing Concrete from Transit Mixers.

A device, which has been developed for distributing ready-mixed concrete from transit mixers, comprises a conveyor and a chute (*Fig.* 1) attached to the vehicle and enables concrete to be placed anywhere within a semi-circle of 25-ft. radius from the back of the vehicle. The conveyor is driven by a hydraulic motor which derives its power from the hydraulic system of the mixer. About ¼ cu. yd. of concrete can be delivered per minute.

A Model Shell Roof.

A model reinforced concrete cylindrical shell roof has been tested to destruction. The model was 18 ft. long, the chord 9 ft., the radius 7 ft., and the thickness ⅜ in. It had, along the longer edges, beams 12 in. deep and 2½ in. wide, and solid-slab end-frames 2 in. thick. The shell was reinforced with a mesh of steel bars at the top and bottom faces. The main reinforcement of each of the edge beams was two ¾-in. mild-steel bars near the lower edge. The load was distributed over the surface of the shell and along the edge beams in such proportions as to represent increasing multiples of the dead load of the roof. Strains were measured at a number of places by means of Galileo lever-type strain gauges, and deflections were measured with dial gauges and sliding gauges. The shell, having previously been subjected to various loadings

Fig. 1.

A new subway under an old building

This new subway, which we have constructed under an existing building at the Works of Messrs. Copper and Alloys Ltd., West Bromwich, was driven through filled ground for 255 feet. It is one of the latest examples of our work in reinforced concrete, and is an illustration of work carried out under exacting conditions.

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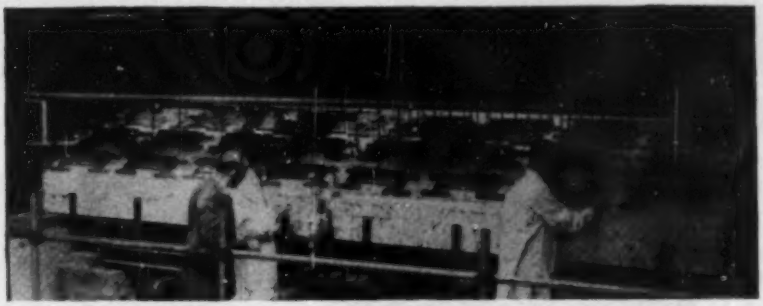

Fig. 2.

and to the effects of shrinking, already had a number of cracks. A record was kept throughout the test of the opening of these cracks and of the incidence of new cracks. *Fig.* 2 shows readings being taken at an early stage of the test.

Failure occurred by yielding of the main reinforcing bars in the bottom of the edge beams at mid-length of the shell. The first bar yielded at a total load of 55,000 lb. and the fourth at 74,000 lb. After this, the load could not be increased since the shell continued to deflect at this load with considerable change in the shape of the transverse cross-section. There were no signs of buckling due to longitudinal compressive stresses, the maximum values of which were only about 700 lb. per square inch. After one month, strain-hardening and ageing of the steel had produced an increase in the yield-point stress such that it was possible to increase the load on the shell to 80,000 lb. before further yielding of the main bars was initiated. There were still no signs of buckling of the shell. Immediately after reaching the new yield there was incipient collapse of one corner of the shell proper, due in the first place to a progressive reduction of the shearing resistance along the junction between the shell and the end frame, the shell tearing away as the diagonal tension/diagonal compression mechanism broke down. An earlier shell having failed in transverse bending, each of the three possible major methods of failure of this type of shell has now been encountered.

Demand for Reinforcement.

The demand in Great Britain for reinforcement is likely to increase from 450,000 tons in 1959 to 800,000 tons in 1965, it is estimated by the Reinforced Concrete Association's Committee on Steel Supplies. The estimate was made early last year, and it now seems likely that the estimated weight of 600,000 tons for 1960 will be exceeded owing to the demand being unprecedented. Some of the reasons for the rapid growth in demand, and for that expected in the future, are stated to be, that with the higher cost and reduced availability of land, there is a trend towards tall blocks of flats and offices; the use of reinforced concrete in bridges and in other civil engineering works is increasing; and the development of lightweight reinforced concrete for facing slabs and structural members. The ratio between tonnage of reinforcing steel used and the population is lower in Britain than in some continental countries.

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A Prison Wall.

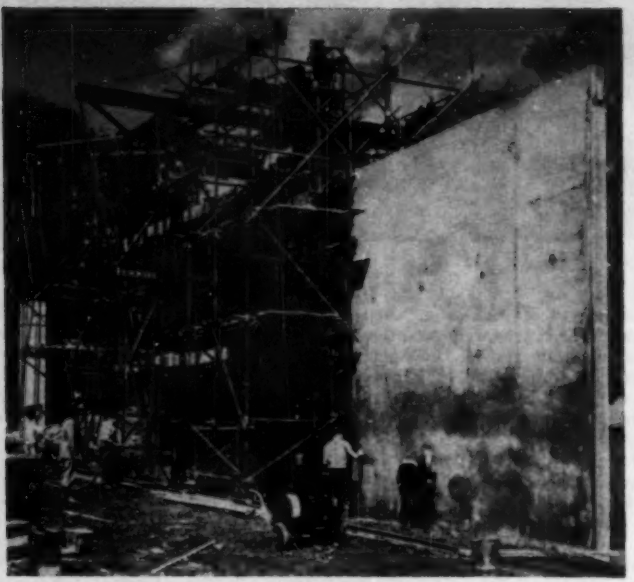

Fig. 1.

THE 18-ft. wall (*Fig.* 1) around the new Psychiatric Prison at Grendon Hall, Bicester, is of reinforced concrete construction and is 9 in. thick and about 3000 ft. long.

The shuttering was of steel construction and used in the form of a complete unit, travelling on rails, enabling the wall to be built in bays each 20 ft. long. Before the shuttering was moved into position for concreting a bay, the base of the wall was built and the steel reinforcement for one bay of wall erected. The shuttering was then moved into position and fixed. The concrete was elevated by hoists attached to the framing of the shuttering. The placing of the concrete was continuous for the full height of the wall. Consolidation was by means of electric vibrators of the poker type, which were raised gradually as placing of the concrete continued. It was possible for one complete bay of the wall to be concreted each day. The top of the wall is surmounted by a precast concrete coping.

The new prison has been designed by the Chief Architect's Division of the Ministry of Works in consultation with the Director of Works of the Prison Commission. Turriff Construction Corporation, Ltd., were the main building and civil engineering contractors.

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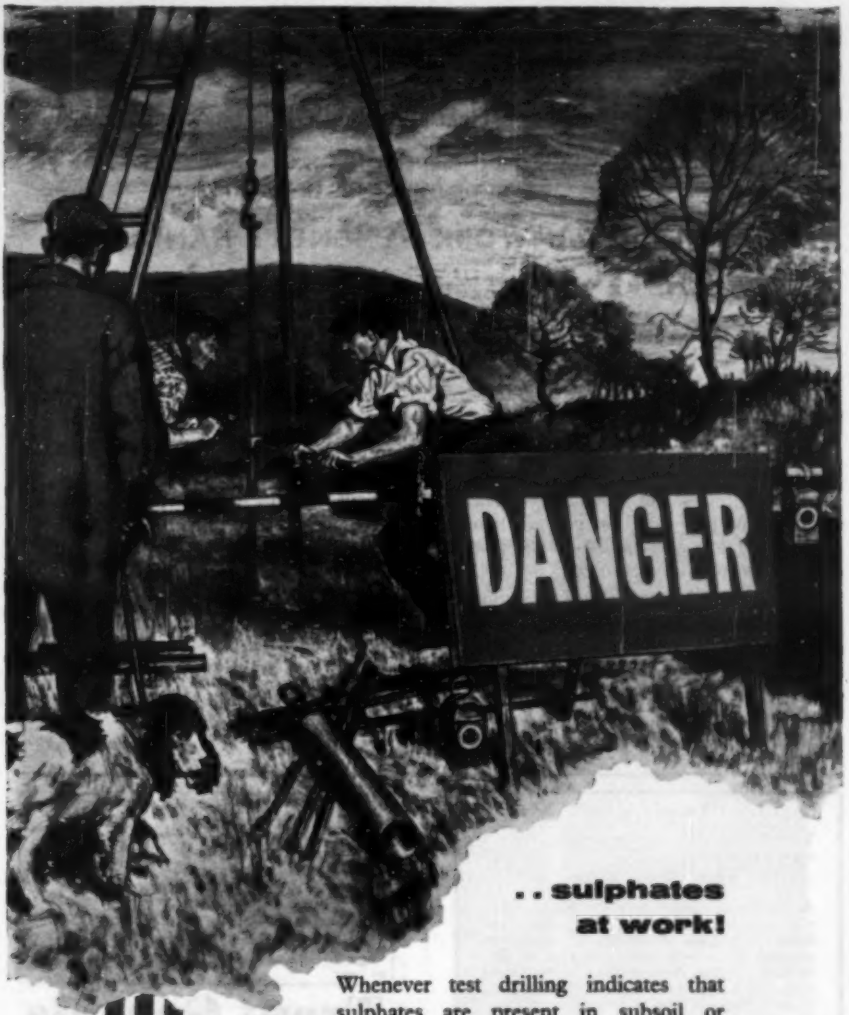
A CEMENTITIOUS composition for lining tanks of steel, concrete, or ferro-concrete comprises 2 parts Portland cement, 1 part fine quartz powder and 10–15 per cent. (based on the weight of cement) of a 60 per cent. aqueous polyvinyl acetate dispersion. The dispersion is mixed with the water to be used for mixing the cement and then added to the mixture of cement and quartz. The dispersion may be replaced by a rubber or neoprene latex.—No. 836,129. Gewerkschaft Keramchemie. October 19, 1956.



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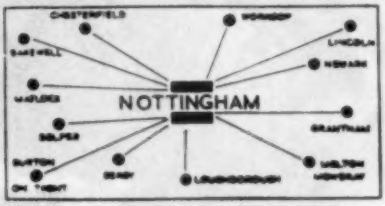

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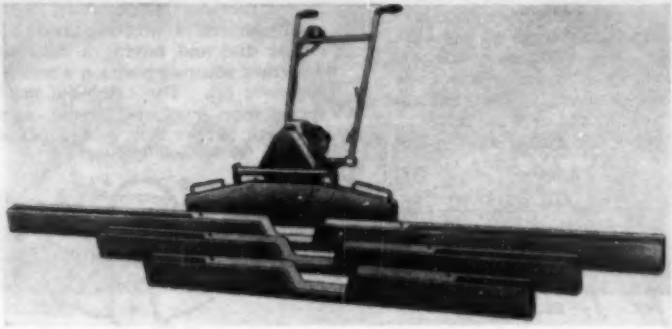


Fig. 1.

A Surface Vibrator.

In *Fig.* 1 is shown a Swedish machine for levelling and vibrating slabs. The machine may be driven by a 1-h.p. electric motor or a petrol engine and is supplied with interchangeable vibrating tampers 5 ft., 6 ft. 6 in., and 10 ft. long which enables the concrete to be spread, tamped, and smoothed in one operation. It is claimed that its capacity is up to 900 sq. ft. of concrete an hour. The machine is sold in this country by Machinery (Continental), Ltd.

Determining the Hardness of Mortar.

A new instrument (*Fig.* 2) is available for determining the rate of hardening of mortars abstracted from concrete mixtures by sieving. A rod is thrust into a sample of the mortar 1 in. thick and the resistance to penetration is indicated in pounds by the compression of a calibrated spring. The instrument may be used to determine the effects of such variables as temperature, amount of cement, mixture and additives, upon the hardening of concrete. Six rods, the areas of the ends of which range from 0·025 sq. in. to 1 sq. in., are supplied with the instrument, which is called a Mortar Penetrometer, and is obtainable from Soiltest Inc., Chicago, Illinois, U.S.A.

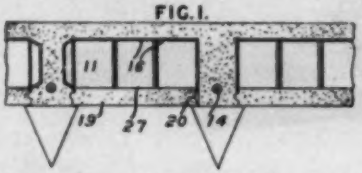
Fig. 2.

Patent Applications.

Floors.

A CONCRETE floor is made by placing cores 11 having open bottoms 27 on precast concrete blocks 19 on which they are located by lips 20 on the cores and casting concrete around and over the boxes. Prestressed reinforcing rods 14 are laid between the cores. The cores comprise a

FIG. 1.

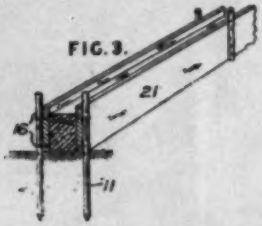


number of boxes 16 connected by staples and made of waterproof cardboard, and may be folded flat and may contain horizontal and vertical partitions (*Fig.* 3, not shown). —No. 829,308. Udalls Prestressed Concrete Ltd. July 5, 1957.

Shuttering for Casting Concrete.

METAL stakes 11 for supporting forms 21 in which concrete is cast have holes, for the form fastenings 16, diametrically through and spaced along the post and arranged so that there are one or more hole openings for every 60 degrees of

FIG. 3.



angular measurement about the axis of the post. Thus, however the stake is driven, there is always one or more holes at less than 30 degrees to perpendicular to the forms, to allow satisfactory fastening.—No. 829,264. C. & H. Specialties Co. March 5, 1958.

Concrete Spacers.

A DISC (1) of concrete or the like for spacing reinforcement in concrete structures has a slot (2) which receives the reinforcing member, the disc being retained thereon by a resilient deformable catch-element (6) pivoting about a hole (5) in the disc and having a relatively less deformed securing position where it enters a groove (4). The catch (6) may be of spring wire, synthetic plastic, natural or synthetic rubber bent into elliptical form.

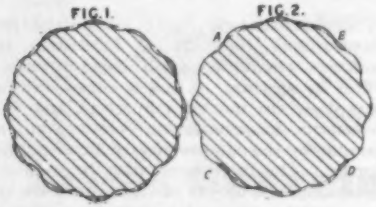
FIG. 3.

In modifications the catch (6) may be in the form of a J, the short arm of which engages the hole (5), or alternatively a blind hole may be provided and the catch element inserted when the disc is in position. Specification 789,018 is referred to. —No. 818,538. F. W. Berry. January 20, 1958.

Twisted Reinforcing Bars.

A TWISTED reinforcing bar for reinforced concrete has a constant cross-sectional area throughout its length, the shape of the cross section varying progressively and continuously along the length of the bar to prevent untwisting thereof in the concrete. In *Fig.* 1 the bar is provided

FIG. 1. FIG. 2.



with helicoidal grooves the width and depth of which vary simultaneously and inversely along the length of the bar to provide grooves of different shape whilst maintaining constant cross-sectional area of the bar. In a modification (*Fig.* 2), only some of the grooves over the areas AB and CD are varied in shape.—No. 818,277. A. Sarrasin and P. Sarrasin. October 23, 1956.

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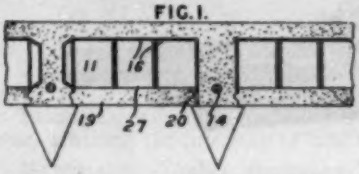
Patent Applications.

Floors.

A CONCRETE floor is made by placing cores 11 having open bottoms 27 on precast concrete blocks 19 on which they are located by lips 20 on the cores and casting concrete around and over the boxes. Prestressed reinforcing rods 14 are laid between the cores. The cores comprise a

FIG. 1.

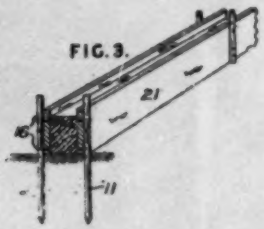


number of boxes 16 connected by staples and made of waterproof cardboard, and may be folded flat and may contain horizontal and vertical partitions (*Fig.* 3, not shown). —No. 829,308. Udalls Prestressed Concrete Ltd. July 5, 1957.

Shuttering for Casting Concrete.

METAL stakes 11 for supporting forms 21 in which concrete is cast have holes, for the form fastenings 16, diametrically through and spaced along the post and arranged so that there are one or more hole openings for every 60 degrees of

FIG. 3.



angular measurement about the axis of the post. Thus, however the stake is driven, there is always one or more holes at less than 30 degrees to perpendicular to the forms, to allow satisfactory fastening.—No. 829,264. C. & H. Specialties Co. March 5, 1958.

Concrete Spacers.

A DISC (1) of concrete or the like for spacing reinforcement in concrete structures has a slot (2) which receives the reinforcing member, the disc being retained thereon by a resilient deformable catch-element (6) pivoting about a hole (5) in the disc and having a relatively less deformed securing position where it enters a groove (4). The catch (6) may be of spring wire, synthetic plastic, natural or synthetic rubber bent into elliptical form.

FIG. 3.

In modifications the catch (6) may be in the form of a J, the short arm of which engages the hole (5), or alternatively a blind hole may be provided and the catch element inserted when the disc is in position. Specification 789,018 is referred to. —No. 818,538. F. W. Berry. January 20, 1958.

Twisted Reinforcing Bars.

A TWISTED reinforcing bar for reinforced concrete has a constant cross-sectional area throughout its length, the shape of the cross section varying progressively and continuously along the length of the bar to prevent untwisting thereof in the concrete. In *Fig.* 1 the bar is provided

FIG. 1.

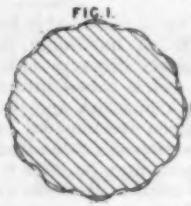


FIG. 2.

with helicoidal grooves the width and depth of which vary simultaneously and inversely along the length of the bar to provide grooves of different shape whilst maintaining constant cross-sectional area of the bar. In a modification (*Fig.* 2), only some of the grooves over the areas AB and CD are varied in shape.—No. 818,277. A. Sarrasin and P. Sarrasin. October 23, 1956.

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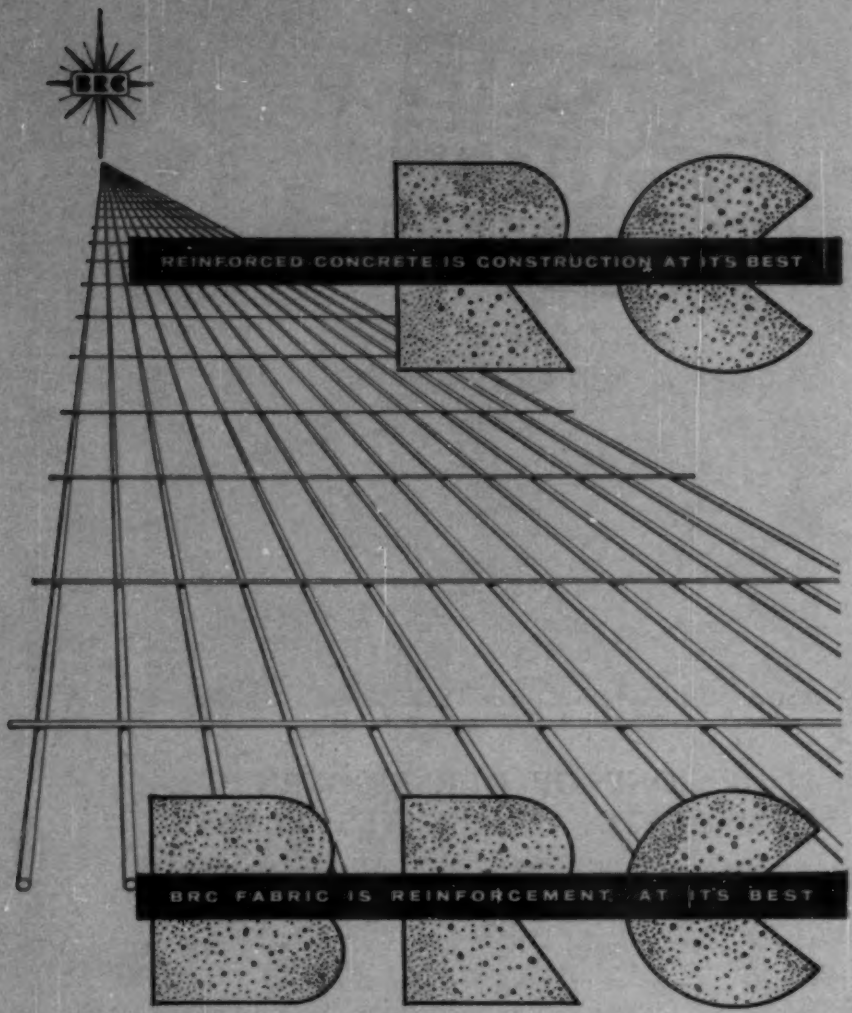

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